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A STUDY OF AQUATIC CONDITIONS IN LAKE ECHO DURING 1984

BY

P. R. HINCH AND J. K. UNDERWOOD

NOVA SCOTIA DEPARTMENT OF THE ENVIRONMENT

P.O. BOX 2107

HALIFAX, NOVA SCOTIA

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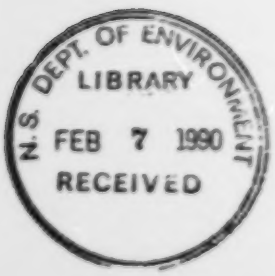

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I INTRODUCTION:

On May 17, 1984, Nova Scotia Department of the Environment was approached by Hon. T. McInnis, Minister of Municipal Affairs, to address a public concern of the residents within the Lake Echo area about what was considered to be a deterioration in water quality. We responded to this request by developing a study program in conjunction with Nova Scotia Department of Health.

A public meeting was held in July, 1984, to clearly define resident's concerns and to ensure the design of our program would meet those concerns. A Lake Echo citizens committee was elected to represent the resident body. Residents contend that during the elapsed time since the two bridges of Highway #107 were constructed in (1978), bisecting Lake Echo, water levels of the lake have risen causing flooding and septic system malfunctions. They also believe that water flow within the northern most sector of the lake has been reduced as has water exchange between the two sectors of the lake above and below the bridges. As a result, there is a concern about accelerated rates of sediment accumulation in the lake. Most important of all their concerns was the profuse growth of aquatic plants which is reportedly spreading further each year into the centres of several coves, with resultant interference with boating and swimming activities. Finally, during the month of June, 1984, we received complaints of two separate incidences of fish kills of gasperaux and consequent expressions of concern for drinking and swimming water quality.

We saw as our central purpose of the study the determination of the possible cause(s) of aquatic plant through: 1) delineation of potential sources of nutrient input into the lake which could stimulate or accelerate lily growth; 2) the design of a four month sampling program for assessment of chemical and bacteriological water quality; 3) measurement of water flow above and below the bridges.

Specific objectives were as follows:

1. Chemical water quality. 1) to locate (by map) sampling locations and areas of concern to the residents; 2) to note variations in monitor chemical composition over the summer and fall months; 3) to try to distinguish changes in water quality due to human influence from those

caused by natural phenomena; and 4) to determine the degree of nutrient enrichment (trophic state) of the lake.

2. Microbiological considerations. 1) to undertake bacterial analyses of lake, inlet, and outlet waters for species composition, 2) to characterize sources of bacterial input; 3) to determine the extent of use of sewage and septic systems and their operation efficiency through dye testing.

3. Hydrological characteristics. To examine hydrological features of the lake area by: 1) determining water levels at the bridges; 2) determining peak water levels in the lake; and 3) defining the drainage area; 4) developing watershed features to characterize the geological features of the surrounding terrain (soil, bedrock and slope, drainage pattern) in conjunction with land use practice and development to ascertain the potential effect of drainage on water quality, i.e. the contribution of natural elements to the chemical composition of the lake through drainage.

II DATA PRESENTATION

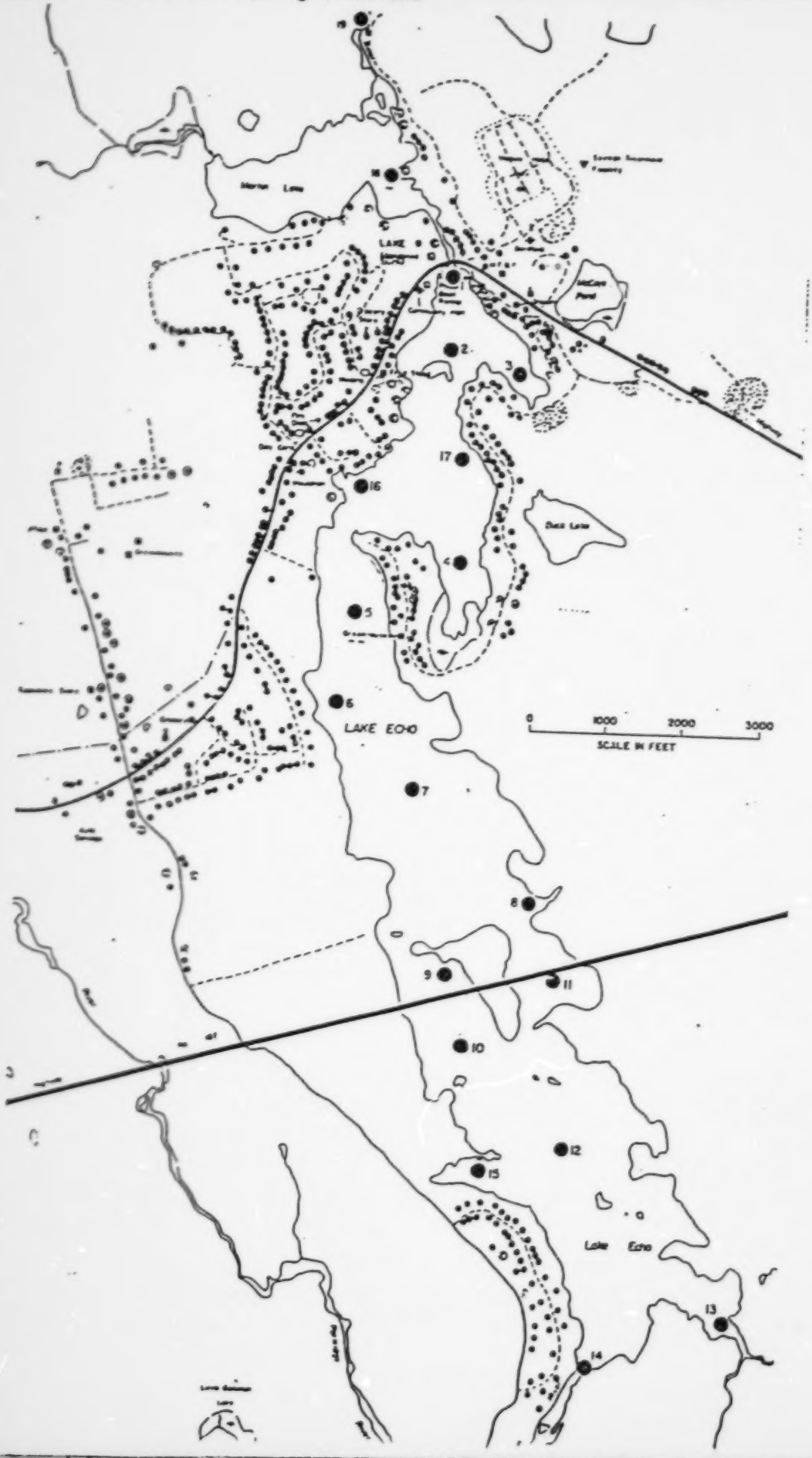
A. LAKE CHEMISTRY:

(a) Program outline and methodology.

Sampling locations for nineteen stations were carefully selected and distributed along the entire length of Lake Echo. For sampling purposes, the lake was divided into three distinct basins - the upper northern-most sector (including stations 1-4, 16 and 17), the middle sector immediately north of the bridges of highway #107 (stations 5-9) and the southern-most sector south of the bridges (stations 10-15). In addition, two sampling locations were selected for Martins Lake (stations 18 and 19). The stations are shown on Figure 1.

In the selection of sample stations, particular attention was given to areas of concern of the residents. These areas of concern included: coves having reportedly high levels of aquatic plant growth (station 3 and 4), points of suspected discharge or runoff (station 16), points above and below the bridges

Figure 1 Lake Echo Sampling Locations



(stations 9, 10, and 11), and Martins Lake (stations 18 and 19). In addition, three mid basin stations (stations 12, 7, and 2) were selected as were points on outlet (stations 13 and 14) and inlet (stations 1 and 8) streams and rivers, and sectors of the lake near selected residentially developed areas (stations 1-4, 6, 16, 17, 5 and 15).

Lake Echo and Martin were sampled five times during the study period between July and October of 1984. Samples for chemical analysis were taken either at the surface (for inlets or shallow areas) or at mid-depth (where depths permitted), at each of the 19 stations. Three samples were taken at mid-basin stations; one at the surface, one at mid-depth and one near the bottom. Samples for bacterialogical analysis were collected at the surface using prescribed sampling techniques of the Department of Health.

Except for chlorophyll and mercury, no preservatives were added to water samples as they were transported to the laboratory for analysis at the end of each sampling day. Chemical analyses were undertaken for those parameters listed in Table 1.

Water samples for chlorophyll analysis were filtered in the field using an Erylenmeyer flask vaccuum pump apparatus. Magnesium carbonate was added to stabilize samples before filtering.

Samples for mercury analysis were taken from either mid-depth (for sampling stations having a depth of greater than 1 metre) or the surface (for shallow areas less than 1 metre depth) and preserved in the field with potassium dichromate.

Dissolved oxygen and temperature readings were obtained in the field using a YSI oxygen meter (model no. 57).

Bacteriological samples were analyzed for total coliform, fecal coliform, staphylococcus, pseudomonas and fecal streptococcus species.

Lake volume and water surface area were obtained from Sabean (1979). Estimates of flushing rate and the drainage area were obtained from Lewis (1985), Underwood (1985) and Sabean (1979). Lake bathymetry as shown in

TABLE 1 CHEMICAL ANALYSES

Parameter:

Hardness	pH
Alakalinity	Total organic carbon
Sulfate	Total phosphate
Chloride	Total nitrogen
Ortho-phosphate	Aluminum
Nitrate and Nitrite	Boron
Ammonia	Barium
Arsenic	Beryllium
Iron	Cadmium
Manganese	Chromium
Lead	Cobalt
Copper	Nickel
Zinc	Antimony
Total dissolved solids	Selenium
Suspended solids	Tin
Color	Vanadium
Turbidity	Mercury
Conductivity	

Figure 2 was obtained from Sabean (1970). Superimposed are sampling locations and the position of Highway #107.

Trophic classifications were based on OECD probability curves for phosphorus (Vollenweider and Kerekes, 1980).

Means standard deviations, linear regressions, and r^2 coefficients of determination were the four major statistical methods used in analysis of the chemical data.

The relationships which were examined by linear regression, r^2 and statistical mean, were as follows:

(a) Total Phosphorus : Total Nitrogen
(b) Chlorophyll : Total Phosphorus
(c) Total Phosphorus : Color
(d) Iron : Total Phosphorus
(e) Suspended Solid : Total Phosphorus
(f) Color : Chlorophyll
(g) Sodium : Cloride
(h) Calcium : Sulfate
(i) Hardness : Sulfate
(j) Hydrogen ion : Sulfate

This list includes both those parameters associated with productivity and those which permit evaluation of other chemical relationships within the lake.

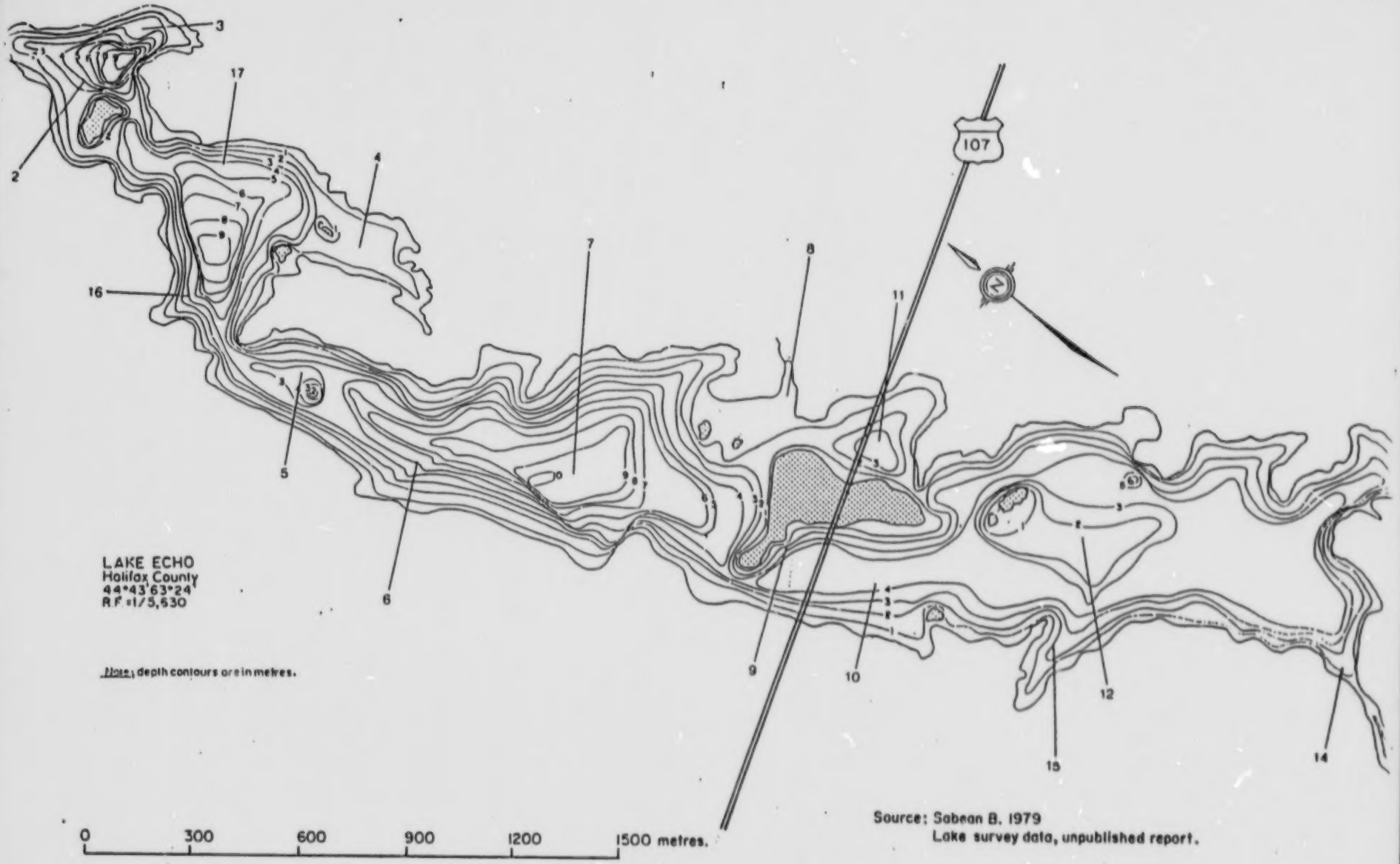
Part I provides an explanation of each chemical parameter analyzed in this study.

Part II describes the treatment of the data and an interpretation of the results.

(b) Chemical Parameters, meaning and significance.

The purpose of this section is to explain the chemical meaning and

Fi$_5$ .e 2 Lake Bathymetry



Source: Sabean B. 1979
Lake survey data, unpublished report.

environmental significance of each chemical substance analyzed by this study. In addition, the data for each Lake Echo parameter is compared against Canadian drinking water standards and average Nova Scotian lake values as a means of assessing water quality.

Total dissolved solid: Total dissolved solid is one component of total residue, the second component being suspended solid. Total residue is the material left in a vessel after water in a sample is evaporated and subsequently dried in an oven at a defined temperature. Suspended solid is that portion of total residue retained by a filter of .45 micron pore size, and total dissolved solid, the portion of total residue that passes through the filter.

The term total dissolved solids, (TDS), refers primarily to inorganic salts and organic matter dissolved in water. Principal ions that contribute to TDS include: carbonate, bicarbonate, chloride, sulphate, nitrate, sodium, potassium, calcium, and magnesium (Health and Welfare Canada, 1978).

TDS may originate either from anthropogenic sources (associated with human activities) such as sewage, urban runoff, salts used for deicing roads and industrial discharges, or from natural sources such as land drainage or the weathering of rock, "waters in contact with granite" (as in the case of Lake Echo), siliceous sand, well-baked soil, or other relatively soluble material commonly have natural background TDS levels of less than 30 mg/1. (Health and Welfard Canada, 1978). The maximum Canadian objective drinking water standard has been set at 500 mg/1. The lower objective limit has not been set because low TDS level waters have a flat insipid taste, i.e. at low levels TDS contributes to the palatability of water (Health and Welfare Canada 1980) aesthetic values being the determining factor. Values of TDS for Lake Echo range from 15.0 to 49.0 mg/1 with an average of 31.4 mg/1. The average value for pristine Nova Scotian lakes is 20 mg/1 with a range of 12.45 to 86.14 mg/1. Lake Echo values fit well within the drinking water limits and background levels for Nova Scotia lake waters.

Suspended solid: The suspended solid component of total residue may consist of clay, silt and finely divided organic and inorganic matter, planktonic and

other microscopic organisms. Maximum acceptable and objective drinking water standards have not been set for this parameter. Excessively high values (e.g. greater than 100,000 mg/l) of suspended solid are aesthetically unsatisfactory and are potentially harmful to the gills of fish and production of phytoplankton (photosynthetic free-floating microscopic plants, the major food source of zooplankton and fish). The average Lake Echo value is 1.987 mg/l with a range of between 0.3 and 34.8 mg/l. The average background Nova Scotian lake concentration is 3 mg/l. There are a few Lake Echo suspended solid values which exceed the Nova Scotian average of 3 mg/l. One possible explanation is that bottom sediment may have been stirred up during sampling and included in the sample bottle.

Total organic carbon: Total organic carbon (TOC) comprises the total of suspended and dissolved organic constituents of water.

Although at present there is insufficient data to set a drinking water limit for TOC, it is recommended that TOC be measured regularily as an indication of the effectiveness of processes used in the purification of drinking water and as an indicator of potential health hazards. (Health and Welfare, 1978).

High levels of TOC are commonly due to the presence of naturally occurring organic matter (humic substances predominantly). Although not in itself a hazard, organic material may provide precursors of potentially harmful contaminants. Humic acids tend to firmly adsorb or complex a wide variety of organic and inorganic pollutants and metals. The ability to complex these substances, particularily heavy metals, may provide a means for the transport of undesirable metals not only within the aquatic system but also from surrounding terrain into the aquatic environment. Metal humate complexes may lead to an underestimation of possible toxic metal ions in waters having high concentration of metal organics. High values (TOC) may also be associated with colour, taste, odour and turbidity problems. (Health and Welfare Canada, 1978).

TOC values for Lake Echo range from less than 0.5 to 7.8 mg/l with an average of 2.87 over the five sampling dates. Pristine Nova Scotian lake values range from .7 to 20 mg/l with an average of 8 mg/l. Lake Echo values are considered low and fall within background levels for Nova Scotia

Chloride: The chloride ion (Cl^-), is one of the most widely distributed inorganic anions in natural waters and wastewaters generally as sodium (NaCl), potassium (KCl) and calcium ($CaCl_2$) salts. The greatest amount of chloride in the environment by far is present in the oceans.

General sources of chloride in natural water are: dissolution of underground salt deposits (dome deposits in Nova Scotia), effluent from chemical industries, oil-well operations, sewage, irrigation drainage, refuse leachates and sea water intrusion into coastal areas. (Health and Welfare, Canada, 1978). Sea spray and sea salt aerosols also contribute significant quantities of salt to this province (Underwood et al, 1984).

In natural water chloride ions chemically form complexes with only a few positively charged ions (e.g. sodium, potassium, and calcium). These complexes are generally considered insignificant - Chloride ions "do not significantly enter into oxidation or reduction reactions, form no important solute complexes with other ions, do not form salts of low solubility, are not significantly absorbed on mineral surfaces and play few vital biochemical roles." (Hem, 1970).

One reason for analysis of chloride, from a human health stand point is, to determine if there is a source of chloride which could potentially affect the taste of drinking water. Potable water may have a detectable salty taste when the concentration of Cl^- in water is 250 mg/l and the cation is sodium. "On the other hand, the typical salty taste may be absent in water containing as much as 1000 mg/l when the predominant cations are calcium and magnesium." (Standard Methods, 14th ed.).

A high Cl content is known to harm metallic pipes, as well as agricultural plants. However, "chloride levels in the body are well regulated, and evidence has not been found to indicate that ingestion of chloride from fresh water sources is harmful to humans. (Health and Welfare, 1978). The objective concentration for chloride is 250 mg/l".

Environmentally, the fact that chloride does not take part in oxidation - reduction reactions to any great extent, makes chloride a useful indicator of the effectiveness of lake mixing and dilution.

Major sources of Cl^- for coastline Nova Scotia is the ocean and road salt. Results for Lake Echo however, have not been corrected for marine Cl^- influence, as correction would not alter the fact that Lake Echo values are very low.

A range of chloride concentration of between 4.0 mg/l and 12.0 mg/l with an average of 5.75 mg/l, fall well within maximum acceptable health concentrations of 250 mg/l.

pH: The pH of a solution is a measure of its hydrogen ion activity (concentration) or more simply stated an indication of the acidity or alkalinity of a solution. The abbreviation "pH" actually represents the negative base $\log_{10}$ of the hydrogen ion activity in moles per litre (Hem, 1970). pH is expressed in logarithmic units of a scale of numbers ranging from 0 to 14. A chemically neutral solution has a value of 7 which is midway on the scale. Solutions having pH readings below 7 are acidic, and above 7 are basic. The term logarithmic means a change of one pH unit downward (upward) e.g. pH 3 to pH 2 (pH 3 to pH 4) implies a tenfold change in the hydrogen ion concentration. A change of two pH units e.g. from pH 3 to pH 1 or pH 3 to pH 5 is a hundredfold increase (decrease) in free acidity.

The pH of natural water is predominantly controlled by carbon dioxide within the water column. pH may also however, be influenced by a number of complex interactions of chemical substances including bases, organic acids, solids, metal oxides, gases, and mineral acidity associated with acid rain and geological formations. Of particular interest with regard to Lake Echo is the fact that Lake Echo lies within the drainage area of the Halifax International Airport. The mineralogy of the airport area is such that when disturbed acidic substances form and are released into the watershed. The mineralogy of the airport may have an influence on the pH of Lake Echo which is situated downstream. More will be discussed on acidity in a subsequent section.

A more thorough discussion of chemical control of pH can be found in any standard textbook in aquatic chemistry.

The pH of natural waters in Nova Scotia ranges approximately from 4.01 to 6.08. Over the four month sampling period in 1984, Lake Echo was found to

have an average pH value of 4.89 with a range of between 4.5 and 5.4, which is consistent with lakes which lie within the Halifax area.

There are no specific health effects on which to base limits for the pH of drinking water. The main purpose in controlling pH is to produce water in which corrosion and in incrustation are minimized.

As a generalization, metal corrosion may become significant below a pH of 6.5, incrustation and scaling problems are most commonly encountered above pH 8.5.

The acceptable range for drinking water pH is therefore from 6.5 to 8.5. In general, waters with a pH within this range can be stablized with respect to corrosion and incrustation by simple pH adjustment. (Health and Welfare, 1980).

Color: The true color of water is defined as the color resulting from substances which are totally dissolved in solution. It is not to be mistaken for apparent color resulting from suspended or colloidal matter.

The color is measured in true color units or TCU. The color in natural waters can be due to one or more of several factors. Color may result from (1) "presence of coloured organic substances (known as humic substances) resulting from the decay or aqueous extraction of natural vegetation (2) the presence of metals such as iron, manganese, and copper which are weathered from rock or corroded from distribution systems by water, or (3) the presence of highly coloured industrial wastes" (Health and Welfare Canada (1980). The color of surface water in Canada is predominantly due to organic substances of natural origin with soft waters being generally more highly coloured than hard waters.

Humic substances are of interest both to environmental and health researchers because humic substances tend to strongly absorb a variety of organic substances many of which have toxic properties. Humic materials also play an essential role in the dissolution, transport, and deposition of inorganic chemical elements, particularly heavy metals. Furthermore, in recent studies color in drinking water has been associated with the formation of organic haloforms which are found when water is chlorinated or similarily disinfected.

Humic substances are environmentally of significance because they impart a certain degree of natural acidity to many lakes in Nova Scotia. Approximately 60% of Nova Scotian lakes have colour values greater than 30 TCU. In addition, the presence of humic substances offers an environmental advantage to fish which live in areas where minerology of the sediments and lakewaters have elevated levels of aluminum. Humic materials bind aluminum making it unavailable for uptake and accumulation in fish gills and subsequent toxic consequences which would occur if aluminum was in a free form.

The maximum acceptable drinking water level for color has been set at 15 TCU and the objective level for color is less than 15 TCU. The average color value for 235 lakes studied in Nova Scotia was found to be 45 TCU. (Underwood, et al. 1982). The range for Lake Echo over the four month sampling period was 10-55 with an average of 8 TCU, slightly above the maximum acceptable limit but in agreement with typical background values for Nova Scotian lakes.

Conductivity: Electrical conductance, or conductivity, is the ability of a substance to conduct an electric current. This value is dependent on the total concentration of substances dissolved in the water and the temperature at which the measurement is made. Most inorganic acids, bases, and salts (such as hydrochloric acid, sodium carbonate, and sodium chloride) are relatively good conductors (Standard Methods, 1975). Molecules of organic compounds (e.g. sucrose, benzene) conduct a current very poorly, if at all. Conductivity is usually measured in umhos/cm.

Maximum acceptable and objective drinking water standards have not been set. However, in a recent study of 37 lakes in the Halifax area carefully selected for their undeveloped watersheds NSDOE found that the conductivity ranged from 24 to 150 umhos/cm with an average of 62.5. Lake Echo with a range of 39 to 71 umhos/cm and an average value of 45.9 umhos/cm, falls well within the norm for this area.

Arsenic: Arsenic is widely distributed in minerals, ores, coal and soil generally as arsenides (As^{3-}) of metals or pyrites. "Arsenic occurs in natural waters in trace amounts either through the dissolution of minerals and ores, or as a contaminant from industrial effluents of coal, metal mining,

refining, and arsenic processing industries and from agricultural and municipal run-off" (Health and Welfare Canada, 1980). Fertilizers and detergents made from phosphate rock containing arsenic, may also be contributory sources.

Arsenic is present in water in either of two chemical forms: trivalent (As III) or pentavalent (As V). Trivalent aresenic as an inorganic species (AsO_3- or AsO_2^{2-}) is formed predominantly in anaerobic (deoxygenated) reservoirs while both trivalent forms are found in groundwater. Pentavalent arsenic as the inorganic species, is the principal form present in well aerated streams.

The toxicity of arsenic compounds to all species "depends on the chemical and physical form of the compound, the route by which it enters the body, the dose and duration of exposure, dietary levels of interacting elements, and the age and sex of the exposed individual. The inorganic arsenicals are more toxic than the organic forms, and of the inorganic forms, the trivalent arsenicals (As III), are more toxic than the pentavalent arsenates (As V).

As there is no evidence of any specific illness association with ingestion of drinking water containing arsenic at a concentration of 0.05 mg/l, the maximum acceptable concentration of arsenic in drinking water is 0.05 mg/l. The objective concentration is less than or equal to 0.005 mg/l. The average Lake Echo concentration and in fact the reading for all data station was less than 0.05 mg/l which is within the maximum acceptable drinking water standard levels.

Environmentally, arsenic is of significance in Nova Scotia because of the prevalance of arsenophyrite. This type of rock is the type commonly associated not only with arsenic but also with gold deposits. During the process of gold mining, the gold is removed leaving arsenic as a waste material in waste rock. Disturbance, exposure of arsenopyrite to the air, and subsequent weathering and/or runoff can contribute a natural source of arsenic to ground and surface water.

Alkalinity: Alkalinity is defined as the capacity of a solution to neutralize acid to a designated pH. There are several solute chemical substances known

to contribute to the alkalinity of water. In most natural water, the alkalinity is practically all produced by dissolved carbonate and bicarbonate ions. In addition, weak acids (such as silicic, phosphoric, boric, and carbonic), organic acids, or a wide variety of dissolved or suspended materials present normally in trace quantities, may be contributory sources to alkalinity.

The average value for Nova Scotia lakes is .65 mg/l with a range of between less than .1 and 1.5 mg/l (Underwood, pers. comm., 1985). The average for Lake Echo was between less than 1.0 and 1.0 mg/l, which is consistent with the Nova Scotian average.

Hardness: The hardness of water is a traditional measure of the capacity of water to react with soap. Excessive soap consumption or use of a considerable but necessary amount of soap to produce a lather in hard water, may lead to leaching and to incrustation of hot water pipes, boilers and other household appliances. Soft water on the other hand, "can lead to corrosion of pipes and consequently certain heavy metals such as copper, zinc, lead and cadmium may be present in the distributed water. The degree to which this occurs is a function of pH, alkalinity, and dissolved oxygen.

Hardness is often discussed in terms of carbornate (temporary) and non-carbonate (permanent) hardness. Carbonate hardness refers to the amount of carbonates and biocarbonates which can be removed or precipitated from solution by boiling. Non-carbonate hardness is caused by the association of the hardness causing cations with sulphates, chlorides, and nitrates. It is also referred to as permanent hardness because it cannot be removed by boiling (Health and Welfare, 1980).

Hardness can originate from either natural or anthropogenic (man caused) sources. The principal natural source of hardness in water are erosion of sedimentary rocks and seepage and runoff from soils. In general, hard waters originate in areas with thick topsoil and limestone formation. The two major industrial sources are inorganic chemical and mining industries.

A maximum acceptable level for hardness has not been established because public acceptance of hardness may vary considerably depending on local

conditions and what communities have become accustomed to. Hardness levels between 80 and 100 mg/l are generally considered to provide an acceptable balance between corrosion and incrustation.

The degree of hardness is expressed as mg/l of an equivalent concentration of calcium carbonate. Soft water is considered to have a value of 0 to 60 mg/l, medium hard 60 to 120 mg/l, hard 120 to 180 mg/l and very hard 180 mg/l and above (Health and Welfare Canada, 1980). Values for Lake Echo range from 6.139 to 9.336 mg/l with an average of 7.644 mg/l placing Lake Echo in the soft water category. Data values of 227.6 for July 12 Station 12, 2 metres, and 33.5 for September 24 Station 5, 3 metre depth are considered as bad data points. The average value for Nova Scotia lakes is 6.0 mg/l (Underwood, pers. comm. 1985). Lake Echo values fall within the norm for this area. However, due to the ultra-soft acidic nature of the water, the potential for leaching of metals from plumbing should be recognized. Problems are easily averted by allowing a tap to run freely several minutes before removing any water for consumptive purposes. Water hardness is caused by dissolved polyvalent metallic ions. In freshwaters, the principal hardness-causing ions are calcium and magnesium. Neither calcium nor magnesium are considered concerns to health.

Metals: The metals which were analyzed by this study included aluminum, antimony, beryllium, barium, boron, cadmium, chromium, colbalt, copper, iron, lead, manganese, nickel, selenium, tin, vanadium, and zinc. All are analyzed on a single automatic machine by a technique known as plasma emission absorption. These metals were not selected for analyses based on the belief that they would definitely be present in Lake Echo above detection levels. Rather they were analyzed because the machine is set up to automatically determine concentrations of all these metals, i.e. it is easier and time saving for the laboratory to analyze for all metals listed above than to set up the machine to measure a select few.

Levels of boron, beryllium, chromium, nickel, antimony, selenium, tin, and vanadium were not detected in Lake Echo, i.e. were below the detection limit capability of the machine. A discussion of potential sources and drinking water standards follows for those metals which did have values above detection levels.

Aluminium: Aluminium is the third most abundant of the elements in the earth's crust. Because of the chemistry of the element however, aluminium concentrations in natural water are low and rarely does it occur in concentrations greater than a few tenths of a mg/l. Exceptions occur in cases where waters have a very low pH.

Aluminium occurs naturally in many silicate, gibbsite, zeolite, and clay rock minerals. The silicates are a potential source of aluminium for the Lake Echo area.

A drinking water standard has not been set for aluminium. A value of .145 mg/l is considered the average background level for Nova Scotian lakes with a range between .008 and .55 mg/l (Underwood, pers. comm. 1985). Concentrations for Lake Echo range from .1 mg/l to .35 mg/l which fall well within the provincial values.

Barium: Barium is a common but trace element in the earth's crust both in igneous and sedimentary rocks (in carbonates, sandstones and shales). Bedrock within the Lake Echo area could be a potential source in nature as basite, a common mineral ($Ba\ SO_4$) and to a lesser extent as witherite ($Ba\ CO_3$).

The maximum acceptable concentration of barium in drinking water is 1.0 mg/l while the objective concentration is less than or equal to 0.1 mg/l. In aquatic systems barium seldom occurs at levels above 1 mg/l. The average concentration for Lake Echo is .007 mg/l with a range of between .005 and .009 mg/l. Concentrations for Nova Scotian lakes have an average value of .017 mg/l (Underwood, pers. comm., 1985).

An isolated high value of 7.0 mg/l was reported on July 12th for station 5, 3 metre depth. It is believed however, that this data point has had a misplacement of the decimal point. The value of 7.0 mg/l is an isolated case, as the majority of other stations had less than or only slightly above detectable limits. The value did not recur with subsequent sampling at the same station. Data for other elements is often reported in ug/l as opposed to mg/l. It is therefore believed that this data point has mistakenly been recorded in ug/l (a thousand times greater than the mg/value). Corresponding

levels of calcium and sulfate which are commonly associated with barium as carbonates and sandstones are low in concentrations.

The majority of Lake Echo barium levels therefore fall within both the drinking water standards and Nova Scotia lake background concentrations.

Cadmium: Cadmium is considered a relatively rare element which is nonetheless uniformly distributed in the earth's crust. Most commonly cadmium is found in association with copper, lead and zinc. In most cases, cadmium occurs as cadmium sulphide, also known as greenockite or cadmium blende often associated with the zinc ore, sphalerite (ZnS). Cadmium occurs in nature in the form of various inorganic compounds and as complexes with naturally occurring chelating agents.

The concentration of cadmium in unpolluted fresh water is generally less than .001 mg/l. Surface water having more than a few micrograms of cadmium per liter have probably been contaminated by industrial wastes (from metallurgical plants, plating works, plants manufacturing cadmium pigments, textile operations, cadmium - stabilized plastics or nickel cadmium batteries) or by effluents from sewer treatment plants. The unintentional presence of cadmium in galvanized products, sewage, sludge and fertilizers and the use of cadmium containing compounds has resulted in a wide spread introduction of cadmium into the environment.

The maximum level acceptable concentration of cadmium in drinking water is 0.005 mg/l. The objective concentration is less than or equal to 0.001 mg/l. Natural waters in Nova Scotia have an average value of less than the detection limit with a range of between less than .005 and .008. The majority of cadmium concentrations for Lake Echo are below the detection limit of .002 mg/l. For those data points above the detection limit the average concentration is .003 mg/l with a range of .002 to .007 mg/l comparable to background levels for Nova Scotian lakes.

A spurious value of 3.1 mg/l was detected in July 12th for station 1, om. It was initially suspected that this cadmium was associated with sewage influx. However, the general chemistry of the sample showed that this was not the

case. Corresponding total phosphorus and total nitrogen levels for Station 1 on July 12, are not elevated and are in fact, comparable to other Lake Echo values. Other indicators of sewage sludge are also weak. The .31 mg/l value may have been due to the possibility that some sediment was sampled along with the lake water. Lake sediments in Nova Scotia an average have a value of .7 mg/l. (Underwood, pers. comm., 1985). This value did not occur in subsequent sampling at Station 1 or any other location. Lake Echo cadmium data, in the vast majority of cases falls within drinking water standards, and comfortably within the background levels for Nova Scotian lakes.

Manganese: Manganese does not occur naturally as a metal, but is present in over one hundred common salts and minerals which are widely distributed in rocks, soils, and on the floors of lakes and oceans. Manganese is most often present in the form of manganese dioxide, manganese carbonate, and maganese silicate. It is invariably present in arable soil and is associated in trace quantities with every kind of plant and animal tissue. (Health and Welfare Canada, 1980).

Manganese compounds which are most commonly found in the earth's crust, the oxides, carbonates and hydroxides are sparingly soluble in natural waters. Weathering of manganese bearing rocks therefore only contributes slightly to the manganese content of natural waters. Manganese is generally present in natural surface waters in dissolved and suspended forms at concentrations less than 0.05 mg/l. Higher levels are either associated with industrial pollution or with reducing conditions such as exist underground and in some lakes and reservoirs. (Health and Welfare Canada, 1980).

The maximum acceptable drinking water standard of 0.05 mg/l is based on aesthetic conditions as manganese is one of the elements lease toxic to mammals. At levels exceeding 0.15 mg/l manganese stains plumbling fixtures and laundry and casues undesirable tastes in beverages. Even at concentrations as low as 0.02 mg/l problems may be encountered; however, it is difficult to remove manganese to concentrations less than 0.05 mg/l (Health and Welfare Canada, 1980). The objective concentration has been set at less than 0.01 mg/l because of potential deposition and staining even at the maximum acceptable level.

The average maganese level in Nova Scotian lakes is 0.06 mg/l with a range of between less than .01 and 1.2 (Nova Scotia Department of the Environment, lake data file, 1985). The average value for Lake Echo is .162 mg/l with a range of .109 to .226 mg/l which is in agreement with the average levels in natural water bodies for this province.

Zinc: Zinc is considered an abundant element constituting .004% of the earth's substance. The most common zinc mineral is sphalerite (ZnS) which is often associated with the sulphides of other metallic elements, for example, lead, copper, cadmium, and iron (Health and Welfare Canada, 1980). Other than natural sources of zinc, various industrial and domestic emissions contribute considerable amounts of zinc to the air and water environment (Primary iron and steel production, primary copper and nickel production, fuel combustion of coal and heavy oils, solid waste incineration, transportation and pesticide application are all potential contributors to zine levels in the environment.

Carbonates, oxides, and sulphides of zinc are sparingly soluble. Zinc therefore occurs in natural waters at low concentrations. Moreover highly soluble forms of chloride and sulphate zinc salts are chemically hydroyzed to form insoluble carbonates and hydroxides. Adsorption of zinc compounds onto sediments further lowers the level of zinc dissolved in the water.

The maximum acceptable concentration of zinc in drinking water of 5.0 mg/l, is based on aesthetic considerations. Water containing zinc levels in excess of 5.0 mg/l has an undesirable taste, and may develop a greasy film when boiled. The objective concentration is less than 5.0 mg/l. Nova Scotian lake values range from 5.0 to .22 with an average level of .014 mg/l. Lake Echo values range from less than .01 (below the detection limit of .01) to .15 mg/l with an average value of .02 mg/l. The Lake Echo zinc concentrations clearly fall within drinking water standards and the norm for Nova Scotian lake water.

Copper: Copper occurs both as a metal and in mineral form commonly as cuprite and malachite. The principal copper metal ores occur as copper sulphides, oxides and carbonates (Health and Welfare Canada, 1980). Copper and its compounds are ubiquitous (found everywhere) in the environment. Copper is therefore often detected in surface water and in some groundwaters. The form copper takes varies depending on the pH, carbonate concentration of the water

and the anions in solution. Copper may occur as soluble (copper chloride, silicate, and sulphate) and insoluble salts (copper, bicarbonate, hydroxide, oxide and sulphide). Above pH 7.0 copper becomes insoluble and precipitates as copper hydroxide and malachite.

The maximum acceptable drinking water standard for copper is 1.0 mg/l based on aesthetic considerations. At concentrations above 1.0 mg/l copper stains laundry and plumbing fixtures. At higher concentrations, copper may impart an undesirable taste to the water and enhance corrosion of aluminum and zinc. The objective concentration for copper is less than 1.0 mg/l. The average copper level in Nova Scotia lakes is .011 with a range of between less than .005 and .17 mg/l. The majority of copper readings for Lake Echo are below the detection limit. For those values which are detectable, the average is .022 with a range of between .01 and .17 mg/l. As such, Lake Echo copper concentrations concur with the Nova Scotian lake average and range and drinking water standard limits.

Cobalt: Cobalt is found as a common constituent of ultrabasic rocks and other types of igneous rock, and a minor constituent of carbonate rocks. Few data on cobalt concentrations are available in the literature partly because, in many waters, the amount present is below the limit of detection (Durum and Haffty, 1961 and Durfor and Beker, 1964). The low cobalt concentrations observed in nature, are believed to be controlled by adsorption of oxides and hydroxides of manganese and iron respectively, by colloidal particles present in sediments and soils (Hem, 1970).

Drinking water standards for cobalt have not been set. The majority of cobalt readings in Nova Scotian lake water are below the detection limit of .01 mg/l with a range of between less than .01 and .08 mg/l (Nova Scotia Department of the Environment chemical data file). The majority of Lake Echo cobalt values are also below the detection limit of .01 mg/l. For detected values, the Lake Echo average was .013 with a range of .01 to .019 mg/l all of which fall within the norm for Nova Scotian lake water.

Lead: Lead is considered a ubiquitous element in the environment being a natural constituent in the earth's crust. "The primary mineral form of lead is galena (lead sulphide) but it also exists in the following minerals:

cerrusite (lead carbonate), angesite (lead sulphate), crocoisite (lead chromate, and morphite (lead phosphate). The main sources of these minerals are igneous and metamorphic rocks." (Health and Welfare Canada, 1980).

Levels of dissolved lead in surface waters are very low due mainly to solubility characteristics. Sulphides, sulphates, oxides, carbonates, and hydroxides of lead are almost insoluble. Carbonates and hydroxides are believed to impose an upper limit on lead concentrations in lakes, rivers and groundwaters. In addition, the association of lead with sediment, suspended particles (e.g. organic matter, hydrous oxides, and clays) also tend to deplete levels of dissolved lead in the water itself. (Health and Welfare Canada, 1980).

The average lead content in Nova Scotian lakes is estimated to be .008 mg/l with a range of between less than 0.05 and .03. The majority of lead values for Lake Echo are below detection limit. For values above the detection limit, levels range from .002 to .005 with an average of .003 mg/l. The maximum acceptable drinking water standard is .05 mg/l while the objective concentration is less than or equal to .001 mg/l. Lake Echo values clearly fall within background levels for Nova Scotian lakes and the drinking water standards.

Total Phosphorus, Total Nitrogen and Chlorophyll A: For a detailed explanation of those substances please refer to Part II which examines the relationships between element pairs.

(c) Statistical analysis and interpretation of results.

An increase in the abundance of aquatic growth is often the result of a water body receiving excessive contributions of phosphorus and nitrogen which, in effect, act as fertilizing elements to plant growth. The addition of nutrients either through natural or artificial means to a body of water, and the subsequent effects of nutrient addition, is termed eutrophication. "Whether eutrophication is deemed good or bad has to do with the age of the lake, the degree of eutrophication and the uses desired of the lake." (Lang and Armour, 1980). "If the results of nutrient addition are desirable (a

greater fish yield from a pond, for example), the increase is looked upon as a fertilizing enrichment. More frequently, however, the results are undesirable, and eutrophication receives the commotation of pollution" (Mortimer, 1969). It is the intention of this study to determine whether Lake Echo is undergoing the process of eutrophication.

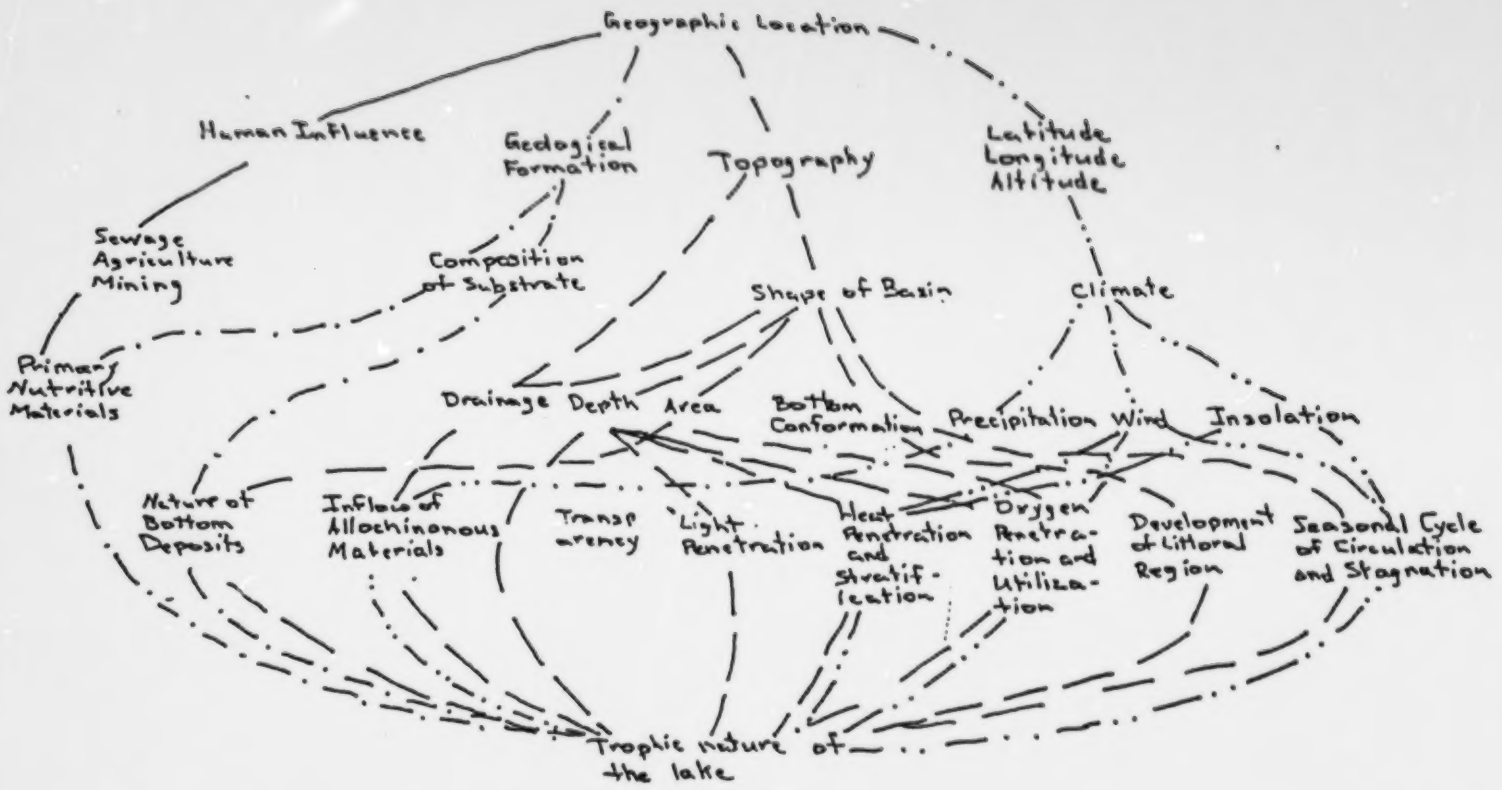
Natural eutrophication refers to nutrient enrichment resulting from natural changes (e.g. forest fires, weathering of rock, soil formation, soil processes, erosion) Natural eutrophication is generally a very slow aging process whereby a body of water is gradually transformed, by accumulation of sediment, to land. The rate of transformation is determined by the physical (e.g. geological formation, flushing time, morphometric properties) chemical (e.g. water quality, nutrient fluxes) and biological (e.g. bacterial, vertebrate, invertebrate, phytoplankton and zooplankton populations) characteristics of the lake and its watershed.

Artificial eutrophication, commonly referred to as cultural eutrophication occurs at a much faster rate than does its natural counterpart, because of the additional nutrient input resulting from human activities. Human sewage, industrial waste, drainage from agricultural land, and urban runoff are examples of nutrient input from human activity.

Lakes are divided into three, sometimes five trophic state categories (or "feeding levels") which serve as an indication of the degree of eutrophication. The five category systems includes ultra-oligotrophic and hypertrophic classifications in addition to the three most common categories: oligo-, meso-, and eutrophic. The terms oligotrophic and eutrophic are synonyms for "poor in nutrients"(or "poorly fed") and "rich in nutrients" (or "well fed") respectively with the mesotrophic classification ("moderately fed") falling between these two in nutrient input. Ultra-oligotrophic has less nutrient input than does oligotrophic and hypertrophic has more nutrient input than does the eutrophic classification.

Many factors can influence the trophic nature of a particular lake as is shown by Fig.3 (Long and Armour, 1980). However, the indices on which tropic classification is commonly based are: nutrient loading level (of total nitrogen and total phosphorus).

Fig. 3



Factors Determining the Trophic Nature

Source: adapted from P.A. Larkin. *Freshwater Pollution. Canadian Style* (Montreal: McGill-Queen's University Press. 1974)

Figure 4

Source: Vollenweider ar. Kerekes 1980

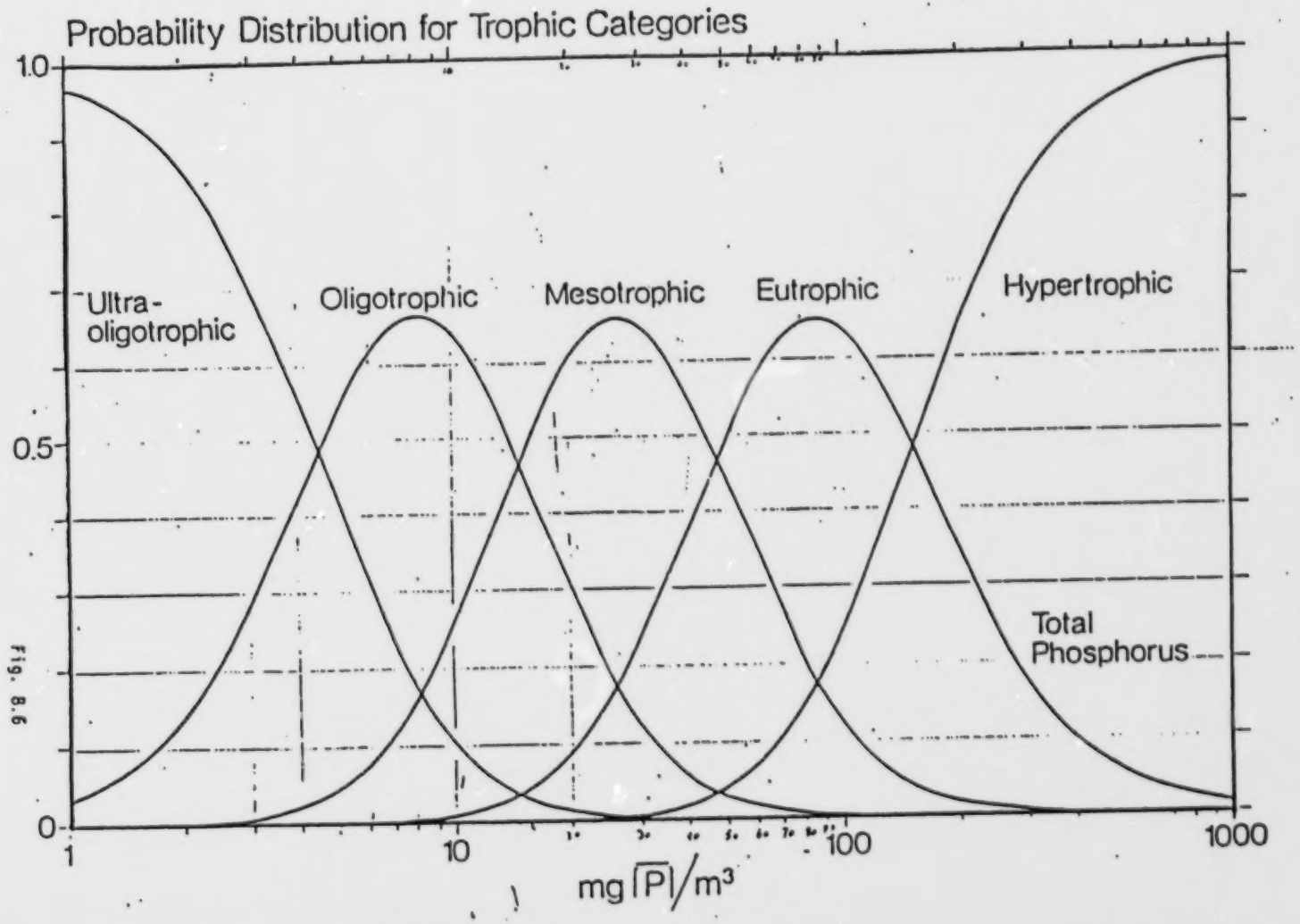
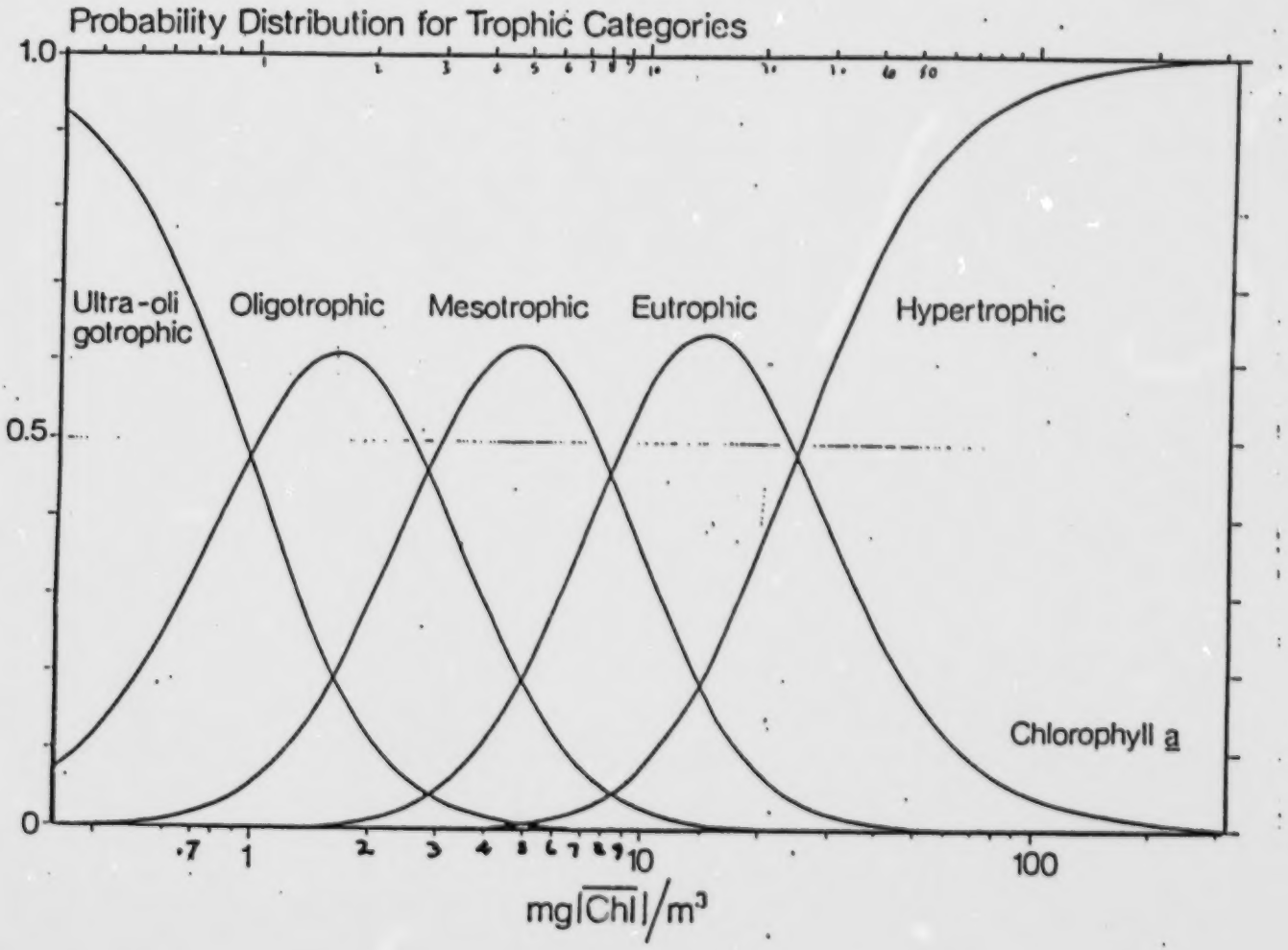


Figure 5

Source: Vollenweider and Kerekes 1980



In the comparison of total phosphorus with OECD probability tables, a mean concentration of 20 mg/m^3 places Lake Echo in the oligotrophic to mesotrophic classification of trophic states (Fig. 4 in Vollenweider and Kerekes, 1980). In the comparison of chlorophyll concentration with OECD probability curves (Fig. 5 in Vollenweider and Kerekes, 1980), an average reading of 0.7 mg/m^3 chlorophyll indicates an ultra-oligotrophic to oligotrophic status. This apparent discrepancy is discussed further under "total:chlorophyll". Other relationships were also examined in order to determine if interferences may have resulted in less than anticipated algal production. In particular, linear regressions were developed between total phosphorus and color, iron, and suspended solids, and between color and chlorophyll. These are discussed in subsequent sections. Relationships were also examined between SO_4, Na, Cl, Ca, hardness and H^+ to investigate other chemical properties (e.g. acidity, marine influence).

Nutrient Analysis

Total Nitrogen : Total Phosphorus: In water, the quantity of dissolved nitrogen and phosphorus compounds available largely control growth rates and abundance of both free floating and rooted aquatic plants. Of any nutrients, it is either of these two nutrients which is most likely to be limiting in supply relative to plant requirements. They are thereby the principle elements controlling the abundance of plant growth. In accordance with Liebig's law of the minimum, "Growth is limited by the substance which is available to it in the minimal quantity relative to its needs for growth and reproduction" (Fricker, 1981). Growth may be influenced by other nutrient elements as well but most often such elements are needed either: (1) in trace quantities but are available in the required quantity and are therefore seldom growth limiting (e.g. trace metals, silicon, vitamin B12) or (2) are so abundant that they are not limiting (e.g. carbon).

The ratio of total nitrogen : total phosphorus is a useful indicator of which of the two parameters is likely acting as the limiting nutrient to plant growth. Fricker (1981) reported that when the ratios of total nitrogen : total phosphorus are in excess of 17, phosphorus is limiting and when less than 10, N limiting. When the ratio is greater than 17, the OECD experience would indicate a relation between algal growth and phosphorus and therefore an

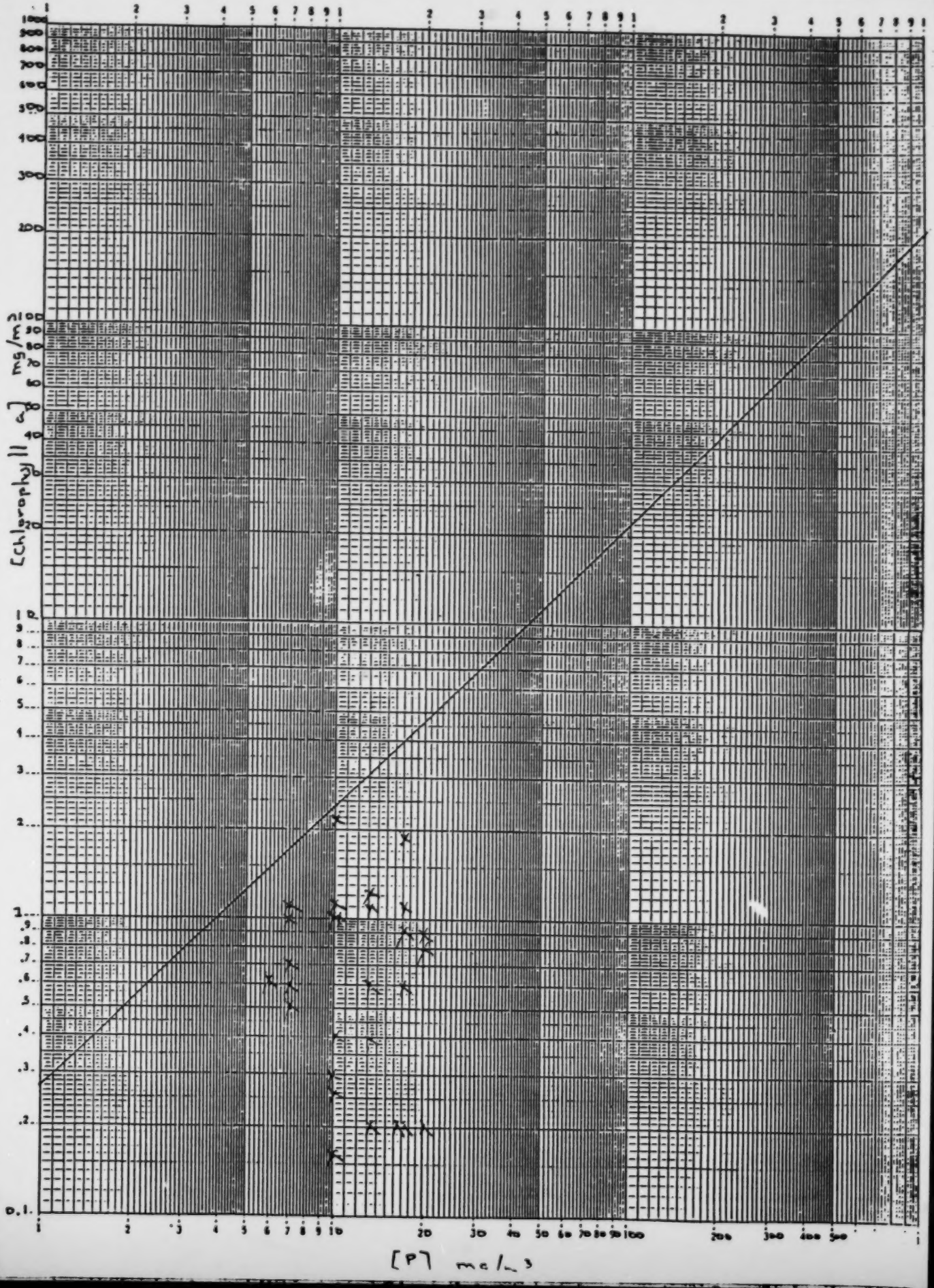
ability to theoretically predict algal growth from phosphorus. When the ratio is less than 10, phosphorus is no longer limiting, meaning that additions of phosphorus do not cause proportional increases in algal growth. In Lake Echo 105 samples were collected in which thirty-two had a ratio greater than 17, thirty had a ratio less than 10, and forty-three had a ratio between 10 and 17. The average ratio value is however 16.5 which indicates Lake Echo has a tendency to be more phosphorus than nitrogen limited. This result is consistent with the OECD study which states that in the majority of lakes studied by the OECD programme, "the production level is controlled by phosphorus, not by nitrogen" (Vollenweider and Kerekes, 1980).

When samples were reported with less than detectable values for total phosphorus, they were excluded from the calculation to avoid potential problems with data interpretation.

Chlorophyll : Total Phosphorus: Total phosphate is regarded as the most important nutrient responsible for the regulation of chlorophyll production and therefore plant growth, depending on its concentration and availability to plant material.

A relationship exists between total phosphorus and chlorophyll if, when phosphorus is the limiting nutrient, plant growth (expressed as chlorphyll concentration), is directly responsive to the level of available total phosphorus. In these circumstances an increase in the concentration of total phosphorus should be indicated by an increase in chlorophyll concentration and therefore the level of plant growth and production.

Figure 6 shows the phosphorus:chlorophyll relationship. Line A-B marks the expected level of chlorophyll production for each given level of available phosphorus (Vollenweider and Kerekes, 1980). For Lake Echo, points occur below the A-B line, meaning chlorophyll is not being produced in quantities that phosphorus concentration might otherwise be expected to support. It was previously noted that comparison of chlorophyll and phosphorus concentrations with OECD tropic probability curves also indicate a lower classification by chlorophyll than is shown by the average Lake Echo phosphorus concentration. Therefore, it is necessary to look for other reasons why chlorophyll concentrations are below those predicted. It is possible that light


[Chlorophyll a] mg/m3
[P] mg/l

penetration was limited or that phosphorus was somehow bound in a form unavailable to stimulate plant growth, and some statistical analyses were conducted to examine these hypotheses. Relationships which were examined to determine the possibility of phosphorus binding include: Total phosphorus:color, total phosphorus:iron, and total phosphorus:suspended solid. Light penetration was assessed by using color data for the lake as Secchi disc transparency was not analyzed.

Total Phosphorus : Color: Colored lakes restrain light penetration. The theory that light is limiting to plant growth for Lake Echo, was however rejected because the color value of the lake water was very low. However, Kerekes (1982) has found that humic lakes have phosphorus to chlorophyll ratios which fall below the phosphorus:chlorophyll line suggesting a binding of total phosphorus to humic material and therefore a lower production of chlorophyll than is indicated by the average total phosphorus concentration.

The relationship of total phosphorus to color was therefore tested to determine if phosphorus is associated with a suspended organic matrix of colored humic material. Results however indicate that this is not the case for Lake Echo, for poor association (r^2 = .01) exists between total phosphorus and color.

Iron : Total Phosphorus: The form and distribution of iron, whether dissolved in the water column or in the interstitial water of sediment, or precipitated and bound by the sediment, is largely dependent upon processes of oxidation and reduction, precipitation and solution of hydroxides, carbonates and sulfides, complex formation especially with organic material, and uptake by aquatic plants. (Hem, 1970).

Of particular importance to the relationship of total phosphorus:iron are the oxidation reduction or redox states and the tendency of iron to form complexes with phosphate. A fluctuation between oxidizing and reducing conditions control the variations in sediment concentrations (or efficiency of precipitation) at the sediment surface, for both iron and total phosphorus. Under oxidized conditions iron and total phosphorus form a complex of iron phosphate (Fe^{3+} PO_4) in the water column. The complex tends to precipitate and accumulate in the uppermost sediment for as long as the top

few millimetres of sediment and lakewater at the water sediment interface are oxygenated. As the flux of total phosphorus from sediments into water is lesser under aerobic (oxygenated) conditions, than under anaerobic (deoxygenated), total phosphorus concentration in top sediment layers can reach significant levels (Hutchinson, 1975). Our experience in other provincial lakes indicates that sediments may contain several thousand times the phosphorus in lake waters.

Should the upper sediment layer become chemically reduced (under anaerobic conditions), iron is transformed to a soluble state, and the phosphorus formerly complexed with it may be released to the water and therefore become available for uptake and stimulation of aquatic growth.

Results indicate a poor association of iron:total phosphorus in the water column ($r^2 = .06$).

Suspended Solid : Total Phosphorus: The relationship between suspended solids and total phosphorus was examined to determine if total phosphorus in the lake is associated with suspended sediments. Suspended sediments may be transported to the lake either from natural sources (e.g. natural runoff, erosion, sediments, weathering of rock) or human (anthropogenic) sources (e.g. sewage, urban runoff, and industrial discharges).

Although the level of significance between total phosphorus and suspended solids was not determined, an r^2 value of .41 is assumed to be significant. Total phosphorus therefore may be bound to suspended solids but not to an extent that this bond interferes with whatever plant productivity and resultant chlorophyll concentrations that do occur within the lake.

III DISCUSSION AND CONCLUSION:

Comparison of Lake Echo phosphorus to chlorophyll relationships with OECD correlations, indicated a chlorophyll value or abundance of planktonic aquatic growth which was less than would be expected given the concentrations of phosphorus which were measured.

Consistent with this result, the trophic classification of the lake, according to OECD chlorophyll probability curves, was lower by one category than the classification predicted by the phosphorus levels. There was an apparent relationship between phosphorus and suspended solid material. Based on this relationship, we suspect that phosphorus is not fully available to stimulate algal growth. We did not actually chemically analyze the suspended solid material so this hypothesis is largely untested.

The average total phosphorus concentration in Lake Echo was 0.02 mg/l. Comparison of this average with phosphorus values for lakes in four Atlantic National Parks (Schwinghamer, 1975) indicate that park lakes have phosphorus concentrations which are on average one half the Lake Echo average value (i.e. 0.01 mg/l or less). A recent survey of pristine lakes near Halifax also indicates low values for total phosphorus (.001 to .017 mg/l). The additional phosphorus requires further examination as to possible source (or sources) of input.

A report by Schwartz and Underwood (1985) were used as reference for a phosphorus loading model for Lake Echo.

Estimates of Lake Echo annual water budget and phosphorus loading:

Annual water budget: There are three estimates of water runoff that are available which range from 89.6 X 10^6 m^3 to 135 X 10^{10} m^3. Flushing also vary in accordance with the runoff estimates, from 19.6 to 29 times per year. For the purposes of this paper, the mean value of the runoff estimates (109 X 10^6 m^3) has been used. This volume results in an estimated flushing rate for Lake Echo of 23.6 times per year, which is equivalent to a water resident time (Tw) of 0.042 years. Table 2 provides a list of various parameters of Lake Echo.

Whole lake phosphorus concentrations and estimates of phosphorus loadings from watersheds.

In order to determine the input of total phosphorus from inlet waters. and the watershed above Lake Echo, a phosphorus budget was developed based on whole lake phosphorus concentrations and the residence time of the lake water

calculation was according to the following formula adapted from Vollenweider and Kerekes (1980):

$$[P]_i = (1 + \sqrt{TW}) \left[\frac{[P]_\lambda}{[1.55]} \right]^{\frac{1}{.82}} \qquad \text{Equation (1)}$$

where:

$[\bar{P}]_i$ is the mean phosphorus concentration of inlet waters (mgm^{-3})

$[\bar{P}]_\lambda$ is the mean annual phosphorus concentration in the lake measured in mgm^{-3}

T(W) is the residence time of water in years

The residence time (T(W)) for Lake Echo water is .042 year and the mean annual phosphorus concentration in the lake $[\bar{P}]$ is 20 mgm^{-3}, which may otherwise be written as .02 mg/L. The total mass of phosphorus in the lake is therefore 92.8 kg given the lake volume of 4.64 X 10^6 m^3. The mean annual external loading of phosphorus inlet waters is by equation (1), 27.2 mg m^{-3} or 3.0 X 10^9 mg which is equivalent to 3.0 tonnes or 3000 kg.

The mean annual phosphorus concentration for Lake Echo of 20 mg m^{-3}, is twice the concentration value of 10 mgm^{-3} found in lakes near Halifax and regional park lakes. If the lake phosphorus concentration were half the value it actually is (e.g. equal to the background concentration level), the external loading of phosphorus would also be less. Substitution of 10 for 20 mg m^{-3} as the P_λ value equation (1) leads to an estimate that the phosphorus loading would be 11.7 mgm^{-3}, equivalent to 1300 kg of phosphorus annually. By subtraction 3000 - 1300 kg of phosphorus leaves 1700 kg of phosphorus added in excess of background loading.

The standard secondary sewage treatment plant receiving 95,000 litres of raw sewage per day will discharge approximately 2.8 kg of phosphorus each day or 1040 kg/year (Table 3). (This is based on the assumption that the standard 95,000 litre capacity treatment plant discharges an average 30 mg of phosphorus/litre of raw sewage received/day (Dennis Ryan, NSDOE, pers. comm., 1985). Therefore, of the 1700 kg of excess phosphorus to be accounted for,

TABLE 2 LAKE ECHO PHYSICAL PARAMETERS AND PHOSPHORUS LOADING ESTIMATES

PARAMETER	VALUE
Volume	4.64 X $10^6 m^3$
Drainage area	115.05 km^3
Volume inflow (runoff)	109 X $10^6 m^3$
Flushing rate	23.6 times/yr.
Residence time	.042 years
Mean annual phosphorus concentration in the lake	.02 mg/L
Mean annual external loading of phosphorus from inlet waters (estimated)	3,000 kg/yr
Mean annual background phosphorus concentration for Halifax vicinity lakes	.01 mg/L
Suggested annual loading based if Lake Echo phosphorus concentration was .01 mg/L	13,000 kg/yr
Excess phosphorus loading (over background)	1,700 kg/yr
Estimated phosphorus from sewage plant	1,040 kg/yr
Estimated phosphorus loading from diffuse flow	660 kg/yr

TABLE 3 ESTIMATE OF PHOSPHORUS LOADING FROM THE SEWAGE TREATMENT PLANT

Parameter	Value
Capacity	95,000 litres/day
Average phosphorus discharge of raw sewage	30 mg/L*
Phosphorus discharge/day	2.8 kg/day*
Annual phosphorus discharge (estimated)	1,040 kg/yr

* Pers. Com. D. Ryan, Nova Scotia Department of the Environment

1040 kg could be accounted for by the sewage treatment plant, leaving 660 kg to be the result of diffuse flow from the watershed.

Thus, if the estimate of phosphorus loading from the sewage treatment plant is reliable, and if phosphorus discharge from septic systems is similar to that presumed above, then point-source discharges above background level would be about 1.6 times the diffuse sources.

Chemical data associated with the STP are very sparce. NSDOH sampled streams in the vicinity of McCoy's pond on July 9, 1984, and there is an indication that phosphorus is lost from the McCoy system before it discharges into the lake. However, this sampling was done during a period of traditional low flow in streams, and when biological systems might be expected to be operating at maximum levels. No sampling was done when the opposite conditions would prevail (i.e. frozen ground, high runoff) so it is not possible to estimate how efficiently McCoy Pond might act as a tertiary treatment system throughout the year. This work could, and should be done.

IV CONCLUSIONS:

Results of this report have indicated:

1. that Lake Echo is chemically safe for drinking purposes according to the drinking water standards set by Health and Welfare Canada (1978);
2. that average total nitrogen levels within Lake Echo are fairly consistent with natural background concentrations found in a 1984 survey of 37 pristine lakes throughout Halifax County. Total phosphorus concentrations of 20 ug/l are however twice the concentrations found for these same pristine study lakes;
3. that based on the average annual concentrations of total phosphorus and nitrogen Lake Echo may be classified as oligotrophic to mesotrophic meaning that it receives low to medium levels of nutrient input;
4. that Wonderland Sewage Treatment has the potential to contribute significantly to the phosphorus input to Lake Echo.

V RECOMMENDATIONS:

As phosphorus loading calculations were based on a small amount of sampling data obtained from the Department of Health, we recommend that a further study be carried out over the summer of 1985 to more fully assess nutrient loading from the Sewage Treatment Plant (STP) under varying stream flow conditions.

APPENDICES

APPENDIX A

Mean values in this report are arithmetic averages.

Standard deviation (S.D.) is a mathematical expression of the amount by which data deviate above and below an average value.

Linear regression is a method of determining whether or not there is a linear relationship between two variables as described by the equation $y = a_1 x + a_0$ where a_1 and a_0 are constants. The purpose of linear regression analysis is to find the value of a_1 and a_0 which give the closest linear agreement between the experimental data and the equation.

The coefficient of determination, r^2, tells how closely a regression equation fits the experimental data i.e. the degree to which the relationship can be described by a straight line. Linearity means in effect that when one parameter increases (or decreases) another parameter responds by increasing (or decreasing) itself, each time in equal proportions. The value of r^2 will lie between 0 and 1. The closer r^2 is to 1, the closer is the relationship between the two variables to linearity.

APPENDIX B

APPENDIX B

Geological and Hydrological Parameters

The Lake Echo area is underlain by the metasediments of the Cambrian aged Meguma Group. This group consists of graywackes and slates of the Goldenville Formation and slates and siltstones of the younger Halifax Formation Overlying the bedrock is a locally derieved sandy slate till and the associated Gilbraltar soils series.

Well yields on the bedrock units are commonly 1-5 IGPM. The quality is generally good with a low level of dissolved solids. The manganese and iron concentrations tend to exceed the guidelines for Canadian Drinking Water Quality. The water can be either corrosive or slightly alkaline depending on the degree of evolution within the groundwater system. In the Lake Echo area secondary mineralization may cause elements such as arsenic to exceed the recommended limits. Water supplies from the surficial material is of similar quality. Slight differences occur in the lower potential for the influence of secondary mineralization and the lower level of neutralizing by evolution of the corrosive precipitation.

APPENDIX C

ALUMINUM

SAMPLING DATE

	July 12	August 3	August 23	September 24	October 25
Station 01	0m - .270	0m - .24 .24	0m - .210	0m - .29	0m - .18
02	0m - .280	0m - .20	0m - .200	0m - .26	0m - .16
	2m - .270	2m - .20	3m - .180	2m - .16	5m - .17
	3m - .290	4m - .23	4.5m - .210	5.0m - .18	11m - .25
03	2.5m - .260	2m - .18	2.25m - .350	2.25m - .26	2.25m - .15
04	1m - .280	.6m - .18	1m - .150	.5m - .20	.5m - .23
05	3m - .330	3m - .19	3m - .160	3m - .33	3m - .14
06	2m - .250		2m - .160	3m - .26	3m - .13
07	2.5m - .260	2.5m - .20	2.5 - .160	2.5m - .23	2.5m - .13
	5m - .280	5m - .21	5m - .160	4m - .13	4m - .13
	7m - .280	8m - .30	7.5m - .490	7.5 - .19	7.5m - .19
08	0m - .260		0m - .140	0m - .22	0m - .14
09	2m - .270	2m - .21	2m - .170	2m - .33	2m - .12
10	0m - .250	0m - .20	0m - .150	0m - .22	0m - .11
11	1.5m - .260		1.5m - .150	1.5m - .13	1.5m - .13
12	0m - .270	0m - .19	0m - .160	0m - .13	0m - .11
	2m - .240	2m - .20	2m - .150	2m - .11	2m - .10
	4m - .300	m - .20	4m - .150	4m - .12	4m - .12
13	0m - .250		0m - .130	0m - .12	0m - .13
14	0m - .250		0m - .150	0m - .11	0m - .11
15	1m - .250		0m - .130	.5m - .09	2m - .12
16		.74m - .20	1m - .160	1m - .16	1m - .16
17		0m - .20	2m - .180	2m - .17	1m - .16
18		1m - .24	0m - .190	0m - .22	0m - .20
		2m - .31	0m - .190	0m - .19	
19		0m - .19	0m - .180	0m - .18	0m - .18

ANTIMONY

SAMPLING DATE

	July 12	August 2	August 23	September 24	October 25
Station 01	0m -< .05	0m - <.05	0m - <.05	0m - <.05	0m - <.05
02	0m -< .05	0m - <.05	0m - <.05	0m - <.05	0m - <.05
	2m -< .05	2m - <.05	3m - <.05	2m - <.05	5m - <.05
	3m -< .05	4m - <.05	4.5m - <.05	5m - <.05	11m - <.05
03	2.5m -< .05	2m - <.05	2.25m - <.05	2.25m - <.05	2.25m - <.05
04	1m -< .05	.6m - <.05	1m - <.05	.5m - <.05	.5m - <.05
05	3m -< .05	3m - <.05	3m - <.05	3m - <.05	3m - <.05
06	2m -< .05		2m - <.05	3m - <.05	3m - <.05
07	2.5m -< .05	2.5m - <.05	2.5 - <.05	2.5m - <.05	2.5m - <.05
	5m -< .05	5m - <.05	5m - <.05	4m - <.05	4m - <.05
	7m -< .05	8m - <.05	7.5m - <.05	7.5 - <.05	7.5m - <.05
08	0m -< .05		0m - <.05	0m - <.05	0m - <.05
09	2m -< .05	2m - <.05	2m - <.05	2m - <.05	2m - <.05
10	0m -< .05	0m - <.05	0m - <.05	0m - <.05	0m - <.05
11	1.5m -< .05		1.5m - <.05	1.5m - <.05	1.5m - <.05
12	0m -< .05	0m - <.05	0m - <.05	0m - <.05	0m - <.05
	2m -< .05	2m - <.05	2m - <.05	2m - <.05	2m - <.05
	4m -< .05	4m - <.05	4m - <.05	4m - <.05	4m - <.05
13	0m -< .05		0m - <.05	0m - <.05	0m - <.05
14	0m -< .05		0m - <.05	0m - <.05	0m - <.05
15	1m -< .05		1m - <.05	.5m - <.05	2m - <.05
16		.75m - <.05	1m - <.05	1m - <.05	1m - <.05
17		0m - <.05	2m - <.05	2m - <.05	1m - <.05
18		1m - <.05	0m - <.05	0m - <.05	0m - <.05
		2m - <.05	0m - <.05	0m - <.05	
19		0m - <.05	0m - <.05	0m - <.05	0m - <.05

ALKALINITY

SAMPLING DATE

	July 12	August 3	August 23	September 24	October 25
Station 01	0m -< 1.0	0m -< 1.0	0m -< 1.0	0m -< 1.0	0m -< 1.0
02	0m -< 1.0 2m -< 1.0 3m -< 1.0	0m - 1.0 2m -< 1.0 4m -< 1.0	0m -< 1.0 3m -< 1.0 4.5m -< 1.0	0m -< 1.0 2m -< 1.0 5m -< 1.0	0m -< 1.0 5m -< 1.0 11m -< 1.0
03	2.5m -< 1.0	2m -< 1.0	2.25m -< 1.0	2.25m -< 1.0	2.25m -< 1.0
04	1m -< 1.0	.6m -< 1.0	1m -< 1.0	.5m -< 1.0	.5m -< 1.0
05	3m -< 1.0	3m -< 1.0	3m -< 1.0	3m -< 1.0	3m -< 1.0
06	2m -< 1.0		2m -< 1.0	3m -< 1.0	3m -< 1.0
07	2.5m -< 1.0 5m -< 1.0 7.0m -< 1.0	2.5m -< 1.0 5m -< 1.0 8m -< 1.0	2.5 -< 1.0 5m -< 1.0 7.5m -< 1.0	2.5m -< 1.0 4m -< 1.0 7.5 -< 1.0	2.5m -< 1.0 4m -< 1.0 7.5m -< 1.0
08	0m -< 1.0		0m -< 1.0	0m -< 1.0	0m -< 1.0
09	2m -< 1.0	2m -< 1.0	2m -< 1.0	2m -< 1.0	2m -< 1.0
10	0m -< 1.0	0m -< 1.0	0m -< 1.0	0m -< 1.0	0m -< 1.0
11	1.5m -< 1.0		1.5m -< 1.0	1.5m -< 1.0	1.5m -< 1.0
12	0m -< 1.0 2m -< 1.0 4m -< 1.0	0m -< 1.0 2m -< 1.0 4m -< 1.0	0m -< 1.0 2m -< 1.0 4m -< 1.0	0m -< 1.0 2m -< 1.0 4m -< 1.0	0m -< 1.0 2m -< 1.0 4m -< 1.0
13	0m -< 1.0		0m -< 1.0	0m -< 1.0	0m -< 1.0
14	0m -< 1.0		0m -< 1.0	0m -< 1.0	0m -< 1.0
15	1m -< 1.0		1m -< 1.0	.5m -< 1.0	2m -< 1.0
16		.75m -< 1.0	1m -< 1.0	1m -< 1.0	1m -< 1.0
17		0m -< 1.0	2m -< 1.0	2m -< 1.0	1m -< 1.0
18		1m -< 1.0 2m -< 1.0	0m -< 1.0 0m -< 1.0	0m -< 1.0 0m -< 1.0	0m -< 1.0
19		0m -< 1.0	0m -< 1.0	0m -< 1.0	0m -< 1.0

AMMONIA

SAMPLING DATE

	July 12	August 3	August 23	September 24	October 25
Station 01	0m - <.05	0m - <.05	0m - <.05	0m - <.05	0m - <.05
02	0m - <.05	0m - <.05	0m - <.05	0m - <.05	0m - <.05
	2m - <.05	2m - <.05	3m - <.05	2m - <.05	5m - <.05
	3m - <.05	4m - <.05	4.5m - .110	5m - <.05	11m - <.05
03	2.5m - <.05	2m - <.05	2.25m - <.05	2.25m - <.05	2.25m - <.05
04	1m - <.05	.6m - <.05	1m - <.05	.5m - <.05	.5m - <.05
05	3m - <.05	3m - <.05	3m - <.05	3m - <.05	3m - <.05
06	2m - <.05		2m - <.05	3m - <.05	3m - <.05
07	2.5m - <.05	2.5m - .08	2.5 - <.05	2.5m - <.05	2.5m - <.05
	5m - <.05	5m - <.05	5m - <.05	4m - <.05	4m - <.05
	7m - <.05	8m - .14	7.5m - .110	7.5 - <.05	7.5m - <.05
08	0m - <.05		0m - <.05	0m - <.05	0m - <.05
09	2m - <.05	2m - <.05	2m - <.05	2m - <.05	2m - <.05
10	0m - .05	0m - <.05	0m - <.05	0m - <.05	0m - <.05
11	1.5m - <.05		1.5m - <.05	1.5m - <.05	1.5m - <.05
12	0m - <.05	0m - <.05	0m - <.05	0m - <.05	0m - <.05
	2m - <.05	2m - <.05	2m - <.05	2m - <.05	2m - <.05
	4m - <.05	4m - <.05	4m - <.05	4m - <.05	4m - <.05
13	0m - <.05		0m - <.05	0m - <.05	0m - <.05
14	0m - <.05		0m - <.05	0m - <.05	0m - <.05
15	1m - <.05		1m - <.05	.5m - <.05	2m - <.05
16		.75m - <.05	1m - .100	1m - <.05	1m - <.05
17		2m - <.05	2m - <.05	2m - <.05	1m - <.05
18		1m - <.05	0m - <.05	0m - <.05	0m - <.05
		2m - <.05	0m - <.05	0m - <.05	
19		0m - <.05	0m - <.05	0m - <.05	0m - <.05

ARSENIC

SAMPLING DATE

	July 12	August 3	August 23	September 24	October 25
		<.005			
Station 01	0m - <.005	0m - <.005	0m - <.005	0m - <.005	0m - <.00
02	0m - <.005	0m - <.005	0m - <.005	0m - <.005	0m - <.00
	2m - <.005	2m - <.005	3m - <.005	2m - <.005	5m - <.00
	3m - <.005	4m - <.005	4.5m - <.005	5m - <.005	11m - <.00
03	2.5m - <.005	2m - <.005	2.25m - <.005	2.25m - <.005	2.25m - <.00
04	1m - <.005	.6m - <.005	1m - <.005	.5m - <.005	.5m - <.00
05	3m - <.005	3m - <.005	3m - <.005	3m - <.005	3m - <.00
06	2m - <.005			3m - <.005	3m - <.00
07	2.5m - <.005	2.5m - <.005	2.5 - <.005	2.5m - <.005	2.5m - <.00
	5m - <.005	5m - <.005	5m - <.005	4m - <.005	4m - <.00
	7m - <.005	8m - <.005	7.5m - <.005	7.5 - <.005	7.5m - <.00
08	0m - <.005		0m - <.005	0m - <.005	0m - <.00
09	2m - <.005	2m - <.005	2m - <.005	2m - <.005	2m - <.00
10	0m - <.005	0m - <.005	0m - <.005	0m - <.005	0m - <.00
11	1.5m - <.005		1.5m - <.005	1.5m - <.005	1.5m - <.00
12	0m - <.005	0m - <.005	0m - <.005	0m - <.005	0m - <.00
	2m - <.005	2m - <.005	2m - <.005	2m - <.005	2m - <.00
	4m - <.005	4m - <.005	4m - <.005	4m - <.005	4m - <.00
13	0m - <.005		0m - <.005	0m - <.005	0m - <.00
14	0m - <.005		0m - <.005	0m - <.005	0m - <.00
15	1m - <.005		1m - <.005	.5m - <.005	2m - <.00
16		.75m - <.005	1m - <.005	1m - <.005	1m - <.00
17		2m - <.005	2m - <.005	2m - <.005	1m - <.00
18		1m - <.005	0m - <.005	0m - <.005	0m - <.00
		2m - <.005	0m - <.005	0m - <.005	
19		0m - <.005	0m - <.005	0m - <.005	0m - <.00

BARIUM (mg/1)

SAMPLING DATE

	July 12	August 3	August 23	September 24	October 25
Station 01	0m - ≤.005	0m - .006	0m - ≤.005	0m - .008	0m - .007
02	0m - .007	0m - .006	0m - .006	0m - .007	0m - .007
	2m - .007	2m - .007	3m - .005	2m - .005	5m - .007
	3m - .007	4m - .007	4.5m - .005	5.0m - .005	11m - .009
03	2.5m - .008	2m - .007	2.25m - .007	2.25m - .007	2.25m - .009
04	1m - .007	6m - .007	1m - .007	.5m - .008	.5m - .007
05	3m - 7.0*	3m - .006	3m - .006	3m - .02	3m - .007
06	2m - .007		2m - .006	3m - .007	3m - .007
07	2.5m - .007	2.5m - .007	2.5 - .006	2.5m - .007	2.5m - .009
	5m - .008	5m - .007	5m - .006	4m - .005	4m - .007
	7m - .007	8m - .007	7.5m - .04	7.5 - .005	7.5m - .008
08	0m - .007		0m - .006	0m - .007	0m - .008
09	2m - .007	2m - .007	2m - .006	2m - .007	2m - .009
10	0m - .007	0m - .009	0m - .006	0m - .007	0m - .009
11	1.5m - .008		0m - .005	1.5m - .006	1.5m - .007
12	0m - .008	0m - .007	0m - .006	0m - .005	0m - .007
	2m - .008	2m - .007	2m - .006	2m - .005	2m - .008
	4m - .007	4m - .008	4m - .006	4m - .005	4m - .007
13	0m - .008		0m - .006	0m - .006	0m - <.005
14	0m - .008		0m - .006	0m - .008	0m - .007
15	1m - .007		0m - .006	.5m - .005	2m - .006
16		.74m - .008	1m - .006	1m - .005	1m - .007
17		2m - .006	2m - .006	2m - .005	1m - .007
18		1m - .006	0m - .007	0m - .005	0m - .005
		2m - .007	0m - ≤.005	0m - .006	
19		0m - .006	0m - <.005	0m - .005	0m - <.005

* sible error in placement of the decimal point

n = 108 (exluding < numbers)
x = .007
S.D. ± .004

BERYLLIUM

SAMPLING DATE

	July 12	August 2	August 23	September 24	October 25
		<.005			
Station 01	0m - <.005	0m - <.005	0m - <.005	0m - <.005	0m - <.005
02	0m - <.005	0m - <.005	0m - <.005	0m - <.005	0m - <.005
	2m - <.005	2m - <.005	3m - <.005	2m - <.005	5m - <.005
	3m - <.005	4m - <.005	4.5m - <.005	5m - <.005	11m - <.005
03	2.5m - <.005	2m - <.005	2.25m - <.005	2.25m - <.005	2.25m - <.005
04	1m - <.005	.6m - <.005	1m - <.005	.5m - <.005	.5m - <.005
05	3m - <.005	3m - <.005	3m - <.005	3m - <.005	3m - <.005
06	2m - <.005		2m - <.005	3m - <.005	3m - <.005
07	2.5m - <.005	2.5m - <.005	2.5 - <.005	2.5m - <.005	2.5m - <.005
	5m - <.005	5m - <.005	5m - <.005	4m - <.005	4m - <.005
	7m - <.005	8m - <.005	7.5m - <.005	7.5 - <.005	7.5m - <.005
08	0m - <.005		0m - <.005	0m - <.005	0m - <.005
09	2m - <.005	2m - <.005	2m - <.005	2m - <.005	2m - <.005
10	0m - <.005	0m - <.005	0m - <.005	0m - <.005	0m - <.005
11	1.5m - <.005		1.5m - <.005	1.5m - <.005	1.5m - <.005
12	0m - <.005	0m - <.005	0m - <.005	0m - <.005	0m - <.005
	2m - <.005	2m - <.005	2m - <.005	2m - <.005	2m - <.005
	4m - <.005	m - <.005	4m - <.005	4m - <.005	4m - <.005
13	0m - <.005		0m - <.005	0m - <.005	0m - <.005
14	0m - <.005		0m - <.005	0m - <.005	0m - <.005
15	1m - <.005		1m - <.005	.5m - <.005	2m - <.005
16		.75m - <.005	.75m - <.005	1m - <.005	1m - <.005
17		0m - <.005	2m - <.005	2m - <.005	1m - <.005
18		1m - <.005	0m - <.005	0m - <.005	0m - <.005
		2m - <.005	0m - <.005	0m - <.005	
19		0m - <.005	0m - <.005	0m - <.005	0m - <.005

CADMIUM

SAMPLING DATE

	July 12	August 2	August 23	September 24	October 25
Station 01	0m - .310	0m - <.002	0m - <.002	0m - <.002	0m - <.002
02	0m - <.002	0m - <.002	0m - <.002	0m - <.002	0m - <.002
	2m - <.002	2m - <.002	3m - <.002	2m - <.002	5m - <.002
	3m - <.002	4m - .002	4.5m - <.002	5m - <.002	11m - <.002
03	2.5m - <.002	2m - .007	2.25m - <.002	2.25m - <.002	2.25m - <.002
04	1m - <.002	.6m - .002	1m - <.002	.5m - <.002	.5m - <.002
05	3m - <.002	3m - .003	1m - <.002	3m - <.002	3m - <.002
06	2m - <.002		3m - <.002	3m - <.002	3m - <.002
07	2.5m - <.002	2.5m - <.002	2.5 - <.002	2.5m - <.002	2.5m - <.002
	5m - <.002	5m - <.002	5m - <.002	4m - <.002	4m - <.002
	7m - <.002	8m - <.002	7.5m - <.02	7.5 - <.002	7.5m - <.002
08	0m - .003		0m - <.002	0m - <.002	0m - <.002
09	2m - <.002	2m - .003	2m - <.002	2m - <.002	2m - <.002
10	0m - <.002	0m - .003	0m - <.002	0m - <.002	0m - <.002
11	1.5m - <002		1.5m - <002	1.5m - <002	1.5m - <.002
12	0m - <002	0m - <002	0m - <002	0m - <002	0m - <.002
	2m - <002	2m - <002	2m - <002	2m - <002	2m - <.002
	4m - <002	4m - <002	4m - <002	4m - <002	4m - <.002
13	0m - <002		0m - <002	0m - <002	0m - <.002
14	0m - <002		0m - <002	0m - <002	0m - <.002
15	0m - <002		1m - <002	.5m - <002	2m - <.002
16		.75m - .004	1m - <002	1m - <002	1m - <.002
17		0m - <002	2m - <002	2m - <002	1m - <.002
18		1m - <002	0m - <002	0m - <002	0m - <.002
		2m - <002	0m - <002	0m - <002	
19		0m - .002	0m - <.002	0m - <002	0m - <.002

CHLORIDE

SAMPLING DATE

	July 12	August 3	August 23	September 24	October 25
		4.0			
Station 01	0m - 4.0	0m - 4.0	0m - 5.3	0m - 4.9	0m - 7.0
02	0m - 5.1	0m - 5.0	0m - 5.6	0m - 5.2	0m - 7.0
	2m - 5.0	2m - 5.0	3m - 7.3	2m - 5.5	5m - 7.0
	3m - 5.0	4m - 5.8	4.5m - 7.8	5m - 5.5	11m - 7.0
03	2.5m - 5.1	2m - 5.2	2.25m - 6.3	2.25m - 5.5	2.25m - 8.1
04	1m - 8.6	.6m - 5.0	1m - 5.9	.5m - 5.5	.5m - 7.0
05	3m - 5.0	3m - 5.0	3m - 5.9	3m - 5.5	3m - 6.4
06	2m - 5.3		2m - 5.3	3m - 8.8	3m - 6.4
07	2.5m - 5.2	2.5m - 5.0	2.5 - 5.3	2.5m - 5.5	2.5m - 6.4
	5m - 5.0	5m - 5.0	5m - 5.6	4m - 5.5	4m - 7.0
	7m - 5.1	8m - 4.8	7.5m - 5.3	7.5 - 5.5	7.5m - 6.4
08	0m - 5.2		0m - 7.4	0m - 12.0	0m - 10.0
09	2m - 5.1	2m - 5.2	2m - 5.9	2m - 6.0	2m - 6.4
10	0m - 5.2	0m - 5.2	0m - 5.6	0m - 6.0	0m - 7.0
11	1.5m - 5.2		0m - 5.9	1.5m - 6.0	1.5m - 7.0
12	0m - 5.2	0m - 5.0	0m - 5.9	0m - 5.8	0m - 7.0
	2m - 5.0	2m - 5.0	2m - 5.9	2m - 5.9	2m - 7.0
	4m - 5.1	4m - 5.0	4m - 5.6	4m - 6.0	4m - 7.0
13	0m - 5.0		0m - 5.6	0m - 5.8	0m - 7.2
14	0m - 5.0		0m - 5.5	0m - 5.8	0m - 7.0
15	1m - 5.2		1m - 4.9	.5m - 5.8	2m - 7.0
16		.75m - 5.0	1m - 5.6	1m - 5.8	1m - 7.0
17		2m - 5.0	2m - 5.9	2m - 5.6	1m - 7.0
18		1m - 4.0	0m - 4.5	0m - 4.5	0m - 5.2
		2m - 4.0	0m - 4.5	0m - 4.8	
19		0m - 4.0	0m - 4.2	0m - 4.2	0m - 5.0

CHLOROPHYLL a (mg/m^3)

	SAMPLING DATE				
	July 12	August 3	August 23	September 24	October 25
Station 01	0m -	0m - .4	0m - .50	0m - 1.2	0m - 1.4
02	0m - .58	0m - .2	0m -	0m - 1.1	0m - .70
03	0m - .56	0m - .3	0m - 1.4	0m - .9	0m - .90
04	0m - .56	0m - .2	0m - .5	0m - 1.0	0m - 1.1
05	0m - .36	0m - .3	0m - .3	0m - .9	0m - .70
06	0m - .48		0m -	0m - 1.2	0m - .60
07	0m - .22	0m - .20	0m -	0m - 1.0	0m - .90
08	0m -		0m -	0m - 2.2	0m - .90
09	0m - .40	0m - .40	0m -	0m - 1.0	0m - 1.1
10	0m - .10	0m - .20	0m -	0m - .90	0m - .60
11	1.5m - .10		0m -	0m - .5	0m - .80
12	0m - .26	0m - .3	0m - .90	0m - .6	0m - .90
13	0m - .16		0m -	0m - .7	0m - 1.1
14	0m - .20		0m -	0m - .6	0m - .80
15	0m -		0m -	0m - .6	0m - .70
16		0m - .2	0m -	0m - .7	0m - .70
17		0m - .3	0m -	0m - .9	0m - .90
18		0m -	0m -	0m - 1.5	0m - 1.9
19		0m -	0m -	0m - .4	0m - 1.0

CHROMIUM

SAMPLING DATE

	July 12	August 2	August 23	September 24	October 25
Station 01	0m - <.01	0m - <.01	0m - <.01	0m - <.01	0m - <.01
02	0m - <.01	0m - <.01	0m - <.01	0m - <.01	0m - <.01
	2m - <.01	2m - <.01	3m - <.01	2m - <.01	5m - <.01
	3m - <.01	4m - <.01	4.5m - <.01	5m - <.01	11m - <.01
03	2.5m - <.01	2m - <.01	2.25m - <.01	2.25m - <.01	2.25m - <.01
04	1m - <.01	.6m - <.01	1m - <.01	.5m - <.01	.5m - <.01
05	3m - <.01	3m - <.01	3m - <.01	3m - <.01	3m - <.01
06	2m - <.01		2m - <.01	3m - <.01	3m - <.01
07	2.5m - <.01	2.5m - <.01	2.5 - <.01	2.5m - <.01	2.5m - <.01
	5m - <.01	5m - <.01	5m - <.01	4m - <.01	4m - <.01
	7m - <.01	8m - <.01	7.5m - <.01	7.5 - <.01	7.5m - <.01
08	0m - <.01		0m - <.01	0m - <.01	0m - <.01
09	2m - <.01	2m - <.01	2m - <.01	2m - <.01	2m - <.01
10	0m - <.01	0m - <.01	0m - <.01	0m - .01	0m - <.01
11	1.5m - <.01		1.5m - <.01	1.5m - <.01	1.5m - <.01
12	0m - <.01	0m - <.01	0m - <.01	0m - <.01	0m - <.01
	2m - <.01	2m - <.01	2m - <.01	2m - <.01	2m - <.01
	4m - .01	m - <.01	4m - <.01	4m - <.01	4m - <.01
13	0m - <.01		0m - <.01	0m - <.01	0m - <.01
14	0m - .01		0m - <.01	0m - <.01	0m - <.01
15	1m - <.01		1m - <.01	.5m - <.01	2m - <.01
16		.75m - <.01	1m - <.01	1m - <.01	1m - <.01
17		0m - <.01	2m - <.01	2m - <.01	1m - <.01
18		1m - <.01	0m - <.01	0m - <.01	0m - <.01
		2m - <.01	0m - <.01	0m - <.01	
19		0m - <.01	0m - <.01	0m - <.01	0m - <.01

COBALT

SAMPLING DATE

	July 12	August 2	August 23	September 24	October 25
Station 01	0m - .012	0m - .018 .010	0m - <.01	0m - <.01	0m - <.01
02	0m - <.01 2m - <.01 4m - <.01	0m - <.01 2m - <.01 4m - <.01	0m - <.01 3m - <.01 4.5m - <.01	0m - <.01 2m - <.01 5m - <.01	0m - <.01 5m - <.01 11m - <.01
03	2.5m - <.01	2m - <.01	2.25m - <.01	2.25m - .01	2.25m - <.01
04	1m - <.01	.6m - <.01	1m - <.01	.5m - <.01	.5m - <.01
05	3m - <.01	3m - <.01	3m - <.01	3m - .012	3m - <.01
06	2m - <.01		2m - <.01	3m - <.01	3m - <.01
07	2.5m - <.01 5m - <.01 7m - <.01	2.5m - <.01 5m - <.01 8m - <.01	2.5 - <.01 5m - <.01 7.5m - <.01	2.5m - <.01 4m - <.01 7.5 - <.01	2.5m - <.01 4m - <.01 7.5m - <.01
08	0m - <.01		0m - <.01	0m - <.01	0m - <.01.
09	2m - <.01	2m - <.01	2m - <.01	2m - <.01	2m - <.01
10	0m - .012	0m - .017	0m - <.01	0m - .01	0m - <.01
11	1.5m - .012		1.5m - <.01	1.5m - <.01	1.5m - <.01
12	0m - <.01 2m - <.01 4m - .01	0m - <.01 2m - <.01 m - <.01	0m - <.01 2m - <.01 4m - <.01	0m - <.01 2m - <.01 4m - <.01	0m - <.01 2m - <.01 4m - <.01
13	0m - <.01		0m - <.01	0m - <.01	0m - <.01
14	0m - <.01		0m - <.01	0m - <.01	0m - <.01
15	1m - <.01		1m - <.01	.5m - <.01	2m - <.01
16		.75m - <.01	1m - <.01	1m - <.01	1m - <.01
17		0m - <.01	2m - <.01	2m - <.01	1m - <.01
18		1m - .01 2m - <.01	0m - <.01 0m - <.01	0m - <.01 0m - <.01	0m - <.01
19		0m - .019	0m - <.01	0m - <.01	0m - <.01

COLOR

SAMPLING DATE

	July 12	August 3	August 23	September 24	October 25
		35.0			
Station 01	0m - 45.0	0m - 25.0	0m - 30.0	0m - 20.0	0m - 17.5
02	0m - 25.0	0m - 30.0	0m - 15.0	0m - 17.5	0m - 17.5
	2m - 25.0	2m - 25.0	3m - 17.5	2m - 17.5	5m - 20.0
	3m - 25.0	4m - 20.0	4.5m - 50.0	5m - 20.0	11m - 25.0
03	2.5m - 25.0	2.0m - 25.0	2.25m - 17.5	2.25m - 17.5	2.25m - 17.5
04	1m - 25.0	.6m - 25.0	1m - 15.0	.5m - 15.0	.5m - 20.0
05	3m - 17.5	3m - 25.0	3m - 12.5	3m - 15.0	3m - 15.0
06	2m - 20.0		2m - 12.5	3m - 15.0	3m - 15.0
07	2.5m - 20.0	2.5m - 20.0	2.5 - 10.0	2.5m - 15.0	2.5m - 15.0
	5m - 20.0	5m - 20.0	5m - 12.5	4m - 17.5	4m - 15.0
	7m - 20.0	8m - 35.0	7.5m - 55.0	7.5 - 17.5	7.5m - 15.0
08	0m - 20.0		0m - 12.5	0m - 20.0	0m - 15.0
09	2m - 20.0	2m - 17.5	2m - 12.5	2m - 15.0	2m - 15.0
10	0m - 17.5	0m - 17.5	0m - 12.5	0m - 12.5	0m - 15.0
11	1.5m - 17.5		1.5m - 10.0	1.5m - 12.5	1.5m - 15.0
12	0m - 17.5	0m - 12.5	0m - 10.0	0m - 10.0	0m - 12.5
	2m - 17.5	2m - 12.5	2m - 10.0	2m - 10.0	2m - 12.5
	4m - 15.0	4m - 17.5	4m - 12.5	4m - 10.0	4m - 12.5
13	0m - 17.5		0m - 10.0	0m - 10.0	0m - 17.5
14	0m - 17.0		0m - 12.5	0m - 10.0	0m - 12.5
15	1m - 17.0		1m - 10.0	.5m - 10.0	2m - 12.5
16		.75m - 25.0	1m - 12.5	1m - 17.5	1m - 17.5
17		2m - 17.5	2m - 12.5	2m - 17.5	1m - 17.5
18		1m - 25.0	0m - 20.0	0m - 20.0	0m - 17.5
		2m - 25.0	0m - 20.0	0m - 17.5	
19		0m - 17.5	0m - 17.5	0m - 15.0	0m - 17.5

CONDUCTIVITY

SAMPLING DATE

	July 12	August 3	August 23	September 24	October 25
		48.0			
Station 01	0m - 42.0	0m - 47.0	0m - 44.0	0m - 45.6	0m - 39.8
02	0m - 43.0	0m - 47.0	0m - 48.0	0m - 45.6	0m - 41.3
	2m - 46.0	2m - 48.0	3m - 51.0	2m - 46.6	5m - 41.3
	3m - 46.0	4m - 50.0	4.5m - 52.0	5m - 47.2	11m - 41.9
03	2.5m - 47.0	2.0m - 48.0	2.25m - 48.0	2.25m - 45.6	2.25m - 45.5
04	1m - 45.0	.6m - 48.0	1m - 46.0	.5m - 45.6	.5m - 40.8
05	3m - 46.0	3m - 49.0	3m - 48.0	3m - 44.5	3m - 41.3
06	2m - 46.0		2m - 48.0	3m - 45.1	3m - 41.6
07	2.5m - 46.0	2.5m - 48.0	2.5 - 48.0	2.5m - 45.6	2.5m - 41.3
	5m - 45.0	5m - 49.0	5m - 46.0	4m - 45.6	4m - 40.5
	7m - 46.0	8m - 46.0	7.5m - 46.0	7.5 - 45.6	7.5m - 40.0
08	0m - 46.0		0m - 52.0	0m - 62.5	0m - 52.0
09	2m - 47.0	2m - 49.0	2m - 48.0	2m - 45.6	2m - 39.8
10	0m - 46.0	0m - 49.0	0m - 46.0	0m - 45.6	0m - 39.8
11	1.5m - 47.0		0m - 46.0	1.5m - 46.1	1.5m - 40.8
12	0m - 46.0	0m - 49.0	0m - 48.0	0m - 45.6	0m - 41.2
	2m - 46.0	2m - 49.0	2m - 46.0	2m - 46.1	2m - 42.3
	4m - 71.0	4m - 49.0	4m - 46.0	4m - 46.6	4m - 41.3
13	0m - 48.0		0m - 46.0	0m - 46.1	0m - 40.8
14	0m - 46.0		0m - 45.0	0m - 45.6	0m - 41.6
15	1m - 47.0		1m - 46.0	.5m - 46.6	2m - 41.2
16		.75m - 48.0	1m - 46.0	1m - 46.1	1m - 41.3
17		2m - 49.0	2m - 46.0	2m - 45.6	1m - 41.9
18		1m - 48.0	0m - 43.0	0m - 46.6	0m - 40.5
		2m - 48.0	0m - 43.0	0m - 46.6	
19		0m - 48.0	0m - 41.0	0m - 46.6	0m - 38.7

COPPER

SAMPLING DATE

	July 12	August 2	August 23	September 24	October 25
		< .01			
Station 01	0m - < .01	0m - < .01	0m - < .01	0m - .01	0m - < .01
02	0m - < .01	0m - < .01	0m - < .01	0m - < .01	0m - < .01
	2m - < .01	2m - < .01	3m - < .01	2m - < .01	5m - < .01
	3m - < .01	4m - < .01	4.5m - < .01	5m - < .01	11m - < .01
03	2.5m - < .01	2m - < .01	2.25m - < .01	2.25m - .02	2.25m - < .01
04	1m - .02	.6m - < .01	1m - < .01	.5m - .03	.5m - < .01
05	3m - .02	3m - < .01	3m - < .01	3m - .03	3m - < .01
06	2m - < .01		2m - < .01	3m - < .002	3m - < .01
07	2.5m - < .01	2.5m - < .01	2.5 - < .01	2.5m - .02	2.5m - < .01
	5m - < .01	5m - < .01	5m - < .01	4m - < .01	4m - < .01
	7m - < .01	8m - < .01	7.5m - .170	7.5 - < .01	7.5m - < .01
08	0m - .01		0m - < .01	0m - .02	0m - < .01
09	2m - .01	2m - < .01	2m - < .01	2m - .01	2m - < .01
10	0m - < .01	0m - < .01	0m - < .01	0m - .01	0m - .02
11	1.5m - < .01		- .02	1.5m - < .01	1.5m - < .01
12	0m - .01	0m - < .01	0m - .01	0m - < .01	0m - < .01
	2m - .01	2m - < .01	2m - < .01	2m - < .01	2m - < .01
	4m - < .01	4m - < .01	4m - < .01	4m - < .01	4m - < .01
13	0m - .01		0m - < .01	0m - < .01	0m - < .01
14	0m - .01		0m - < .01	0m - .01	0m - < .01
15	1m - < .01		1m - < .01	.5m - .01	2m - < .01
16		.75m - < .01	- < .01	1m - < .01	1m - < .01
17		0m - < .01	2m - < .01	2m - < .01	1m - < .01
18		1m - < .01	0m - < .01	0m - < .01	0m - < .01
		2m - < .01	0m - < .01	0m - < .01	
19		0m - < .01	0m - < .01	0m - < .01	0m - < .01

IONS (Hardness) (mg/l) SAMPLING DATE

	July 12	August 3	August 23	September 24	October 25
Station 01	0m - 6.845	0m - 6.803 6.803	0m - 7.220	0m - 7.758	0m - 8.839
02	0m - 7.717 2m - 7.385 3m - 7.426	0m - 7.426 2m - 7.467 4m - 7.967	0m - 7.303 3m - 8.088 4.5m - 8.590	0m - 8.132 2m - 7.717 5m - 8.716	0m - 8.340 5m - 8.422 11m - 8.713
03	2.5m - 7.676	2m - 7.758	2.25m - 7.717	2.25m - 8.132	2.25m - 9.336
04	1m - 7.676	.6m - 7.717	1m - 7.426	.5m - 8.713	.5m - 7.717
05	3m - 7.676	3m - 7.426	3m - 7.426	3m - 33.464	3m - 7.717
06	2m - 7.385		2m - 7.385	3m - 8.173	3m - 7.717
07	2.5m - 7.467 5m - 7.758 7m - 7.758	2.5m - 7.717 5m - 7.717 8m - 7.426	2.5 - 7.426 5m - 7.676 7.5m - 8.258	2.5m - 8.132 4m - 7.426 7.5 - 7.467	2.5m - 8.008 4m - 7.800 7.5m - 7.800
08	0m - 7.509		0m - 7.509	0m - 8.211	0m - 8.005
09	2m - 7.426	2m - 7.717	2m - 7.426	2m - 8.173	2m - 7.758
10	0m - 7.467	0m - 7.467	0m - 7.385	0m - 8.173	0m - 8.049
11	1.5m - 7.426		1.5m - 7.676	1.5m - 7.467	1.5m - 8.049
12	0m - 7.841 2m - 227.618 4m - 7.800	0m - 7.467 2m - 8.049 4m - 7.509	0m - 7.385 2m - 7.426 4m - 7.426	0m - 7.467 2m - 7.509 4m - 7.509	0m - 7.758 2m - 7.758 4m - 7.841
13	0m - 7.758		0m - 7.426	0m - 7.467	0m - 8.129
14	0m - 7.426		0m - 7.135	0m - 7.758	0m - 7.882
15	1m - 7.800		1m - 7.385	.5m - 7.800	2m - 7.841
16		.75m - 7.467	1m - 7.426	1m - 7.467	1m - 8.672
17		0m - 7.676	2m - 7.426	2m - 7.467	1m - 8.381
18		1m - 6.803 2m - 6.803	0m - 5.889 0m - 6.139	0m - 7.094 0m - 7.385	0m - 7.717
19		0m - 6.762	0m - 5.599	0m - 7.635	0m - 6.845

BORON

SAMPLING DATE

	July 12	August 3	August 23	September 24	October 25
		<.02			
Station 01	0m - <.02	0m - <.02	0m - <.02	0m - <.02	0m - <.02
02	0m - <.02	0m - <.02	0m - <.02	0m - <.02	0m - <.02
	2m - <.02	2m - <.02	3m - <.02	2m - <.02	5m - <.02
	3m - <.02	4m - <.02	4.5m - <.02	5m - <.02	11m - <.02
03	2.5m - <.02	2m - <.02	2.25m - <.02	2.25m - <.02	2.25m - <.02
04	1m - <.02	.6m - <.02	1m - <.02	.5m - <.02	.5m - <.02
05	3m - <.02	3m - <.02	3m - <.02	3m - <.02	3m - <.02
06	2m - <.02		2m - <.02	3m - <.02	3m - <.02
07	2.5m - <.02	2.5m - <.02	2.5 - <.02	2.5m - <.02	2.5m - <.02
	5m - <.02	5m - <.02	5m - <.02	4m - <.02	4m - <.02
	7m - <.02	8m - <.02	7.5m - <.02	7.5 - <.02	7.5m - <.02
08	0m - <.02		0m - <.02	0m - <.02	0m - <.02
09	2m - <.02	2m - <.02	2m - <.02	2m - <.02	2m - <.02
10	0m - <.02	0m - <.02	0m - <.02	0m - <.02	0m - <.02
11	1.5m - <.02		1.5m - <.02	1.5m - <.02	1.5m - <.02
12	0m - <.02	0m - <.02	0m - <.02	0m - <.02	0m - <.02
	2m - <.02	2m - <.02	2m - <.02	2m - <.02	2m - <.02
	4m - <.02	m - <.02	4m - <.02	4m - <.02	4m - <.02
13	0m - .25		0m - <.02	0m - <.02	0m - <.02
14	0m - <.02		0m - <.02	0m - <.02	0m - <.02
15	1m - <.02		1m - <.02	.5m - <.02	2m - <.02
16		.75m - <.02	1m - <.02	1m - <.02	1m - <.02
17		0m - <.02	2m - <.02	2m - <.02	1m - <.02
18		1m - <.02	0m - <.02	0m - <.02	0m - <.02
		2m - <.02	0m - <.02	0m - <.02	
19		0m - <.02	0m - <.02	0m - <.02	0m - <.02

NICKEL

SAMPLING DATE

	July 12	August 2	August 23	September 24	October 25
Station 01	0m - <.02	0m - <.02	0m - < .02	0m - .02	0m - <.02
02	0m - <.02	0m - <.02	0m - < .02	0m - < .02	0m - <.02
	2m - <.02	2m - <.02	3m - < .02	2m - < .02	5m - <.02
	3m - <.02	4m - <.02	4.5m - < .02	5m - < .02	11m - <.02
03	2.5m - <.02	2m - <.02	2.25m - < .02	2.25m - .02	2.25m - <.02
04	1m - <.02	.6m - <.02	1m - < .02	.5m - < .02	.5m - <.02
05	3m - <.02	3m - <.02	3m - < .02	3m - .02	3m - <.02
06	2m - <.02		2m - < .02	3m - < .02	3m - <.02
07	2.5m - <.02	2.5m - <.02	2.5 - < .02	2.5m - .02	2.5m - <.02
	5m - <.02	5m - <.02	5m - < .02	4m - < .02	4m - <.02
	7m - <.02	8m - <.02	7.5m - < .02	7.5 - < .02	7.5m - <.02
08	0m - <.02		0m - < .02	0m - < .02	0m - <.02
09	2m - <.02	2m - <.02	2m - < .02	2m - < .02	2m - <.02
10	0m - <.02	0m - <.02	0m - < .02	0m - < .02	0m - <.02
11	1.5m - <.02		1.5m - < .02	1.5m - < .02	1.5m - <.02
12	0m - <.02	0m - <.02	0m - < .02	0m - < .02	0m - <.02
	2m - <.02	2m - <.02	2m - < .02	2m - < .02	2m - <.02
	4m - <.02	m - <.02	4m - < .02	4m - < .02	4m - <.02
13	0m - <.02		0m - < .02	0m - < .02	0m - <.02
14	0m - <.02		0m - < .02	0m - < .02	0m - <.02
15	1m - <.02		1m - < .02	.5m - < .02	2m - <.02
16		.75m - <.02	1m - < .02	1m - < .02	1m - <.02
17		0m - <.02	2m - < .02	2m - < .02	1m - <.02
18		1m - <.02	0m - < .02	0m - < .02	0m - <.02
		2m - <.02	0m - < .02	0m - < .02	
19		0m - <.02	0m - < .02	0m - < .02	0m - <.02

NITRATE AND NITRITE — SAMPLING DATE

	July 12	August 3	August 23	September 24	October 25
Station 01	0m - .130	0m - <.05	0m - <.05	0m - <.05	0m - <.05
02	0m - .07	0m - <.05	0m - <.05	0m - <.05	0m - <.05
	2m - <.05	2m - <.05	3m - <.05	2m - <.05	5m - <.05
	3m - .08	4m - <.05	4.5m - <.05	5m - <.05	11m - <.05
03	2.5m - <.05	2m - <.05	2.25m - <.05	2.25m - <.05	2.25m - <.05
04	1m - <.05	.6m - <.05	1m - <.05	.5m - <.05	.5m - <.05
05	3m - .05	3m - <.05	3m - <.05	3m - <.05	3m - <.05
06	2m - <.05		2m - <.05	3m - <.05	3m - <.05
07	2.5m - .07	2.5m - <.05	2.5 - <.05	2.5m - <.05	2.5m - <.05
	5m - .08	5m - <.05	5m - <.05	4m - <.05	4m - <.05
	7m - .05	8m - <.05	7.5m - <.05	7.5 - <.05	7.5m - <.05
08	0m - .06		0m - <.05	0m - <.05	0m - .13
09	2m - .05	2m - <.05	2m - <.05	2m - <.05	2m - .06
10	0m - <.05	0m - <.05	0m - <.05	0m - <.05	0m - <.05
11	1.5m - .08		1.5m - <.05	1.5m - <.05	1.5m - <.05
12	0m - .09	0m - <.05	0m - <.05	0m - <.05	0m - <.05
	2m - <.05	2m - <.05	2m - <.05	2m - <.05	2m - <.05
	4m - 1.06	4m - <.05	4m - <.05	4m - <.05	4m - <.05
13	0m - .09		0m - <.05	0m - <.05	0m - <.05
14	0m - <.05		0m - <.05	0m - <.05	0m - <.05
15	1m - <.05		1m - <.05	.5m - <.05	2m - <.05
16		.75m - <.05	1m - <.05	1m - <.05	1m - <.05
17		2m - <.05	2m - <.05	2m - <.05	1m - <.05
18		1m - <.05	0m - <.05	0m - <.05	0m - <.05
		2m - <.05	0m - <.05	0m - <.05	
19		0m - <.05	0m - <.05	0m - <.05	0m - <.05

ORTHRO - PHOSPHATE

SAMPLING DATE

	July 12	August 3	August 23	September 24	October 25
		<.02			
Station 01	0m - <.02	0m - <.02	0m - <.02	0m - .05	0m - <.02
02	0m - <.02	0m - <.02	0m - .02	0m - <.02	0m - <.02
	2m - <.02	2m - <.02	3m - <.02	2m - <.02	5m - <.02
	3m - .02	4m - <.02	4.5m - .03	5m - <.02	11m - <.02
03	2.5m - <.02	2m - <.02	2.25m - <.02	2.25m - <.02	2.25m - <.02
04	1m - <.02	.6m - <.02	1m - <.02	.5m - .110	.5m - .03
05	3m - <.02	3m - <.02	3m - <.02	3m - <.02	3m - .02
06	2m - <.02		2m - <.02	3m - <.02	3m - .02
07	2.5m - <.02	2.5m - <.02	2.5 - <.02	2.5m - <.02	2.5m - .02
	5m - <.02	5m - <.02	5m - <.02	4m - <.02	4m - <.02
	7m - <.02	8m - <.02	7.5m - .04	7.5 - <.02	7.5m - <.02
08	0m - <.02		0m - <.02	0m - <.02	0m - <.02
09	2m - <.02	2m - <.02	2m - <.02	2m - <.02	2m - <.02
10	0m - <.02	0m - <.02	0m - <.02	0m - <.02	0m - <.02
11	1.5m - <.02		1.5m - <.02	1.5m - <.02	1.5m - <.02
12	0m - <.02	0m - <.02	0m - <.02	0m - <.02	0m - <.02
	2m - <.02	2m - <.02	2m - <.02	2m - <.02	2m - .07
	4m - <.02	4m - <.02	4m - <.02	4m - <.02	4m - <.02
13	0m - <.02		0m - <.02	0m - <.02	0m - <.02
14	0m - .03		0m - <.02	0m - <.02	0m - .02
15	1m - <.02		1m - <.02	.5m - <.02	2m - .03
16		.75m - <.02	1m - <.02	1m - <.02	1m - .06
17		2m - <.02	2m - <.02	2m - <.02	1m - .05
18		1m - <.02	0m - <.02	0m - <.02	0m - <.02
		2m - <.02	0m - <.02	0m - <.02	
19		0m - <.02	0m - <.02	0m - .03	0m - <.02

pH

SAMPLING DATE

	July 12	August 3	August 23	September 24	October 25
Station 01	0m - 4.6	0m - 4.5 4.6	0m - 4.6	0m - 4.8	0m - 4.9
02	0m - 4.9 2m - 4.6 3m - 4.6	0m - 4.8 2m - 4.6 4m - 4.8	0m - 4.9 3m - 5.1 4.5m - 5.1	0m - 4.9 2m - 5.1 5m - 5.0	0m - 5.1 5m - 5.1 11m - 5.1
03	2.5m - 4.7	2.0m - 4.8	2.25m - 5.0	2.25m - 5.0	2.25m - 5.4
04	1m - 4.7	.6m - 4.8	1m - 4.9	.5m - 5.2	.5m - 5.2
05	3m - 4.8	3m - 4.8	3m - 4.9	3m - 5.2	3m - 5.1
06	2m - 4.8		2m - 4.9	3m - 5.1	3m - 5.1
07	2.5m - 4.7 5m - 4.7 7m - 4.6	2.5m - 4.8 5m - 4.7 8m - 4.8	2.5 - 5.0 5m - 4.9 7.5m - 4.9	2.5m - 5.0 4m - 5.2 7.5 - 5.1	2.5m - 5.2 4m - 5.1 7.5m - 5.1
08	0m - 4.7		0m - 4.9	0m - 5.1	0m - 5.0
09	2m - 4.7	2m - 4.8	2m - 4.9	2m - 5.1	2m - 5.2
10	0m - 4.8	0m - 4.8	0m - 4.9	0m - 5.1	0m - 5.3
11	1.5m - 4.8		0m - 5.0	1.5m - 5.1	1.5m - 5.2
12	0m - 4.8 2m - 4.8 4m - 4.2	0m - 4.7 2m - 4.8 4m - 4.8	0m - 4.9 2m - 4.9 4m - 5.0	0m - 5.2 2m - 5.2 4m - 5.2	0m - 5.3 2m - 5.3 4m - 5.3
13	0m - 4.7		0m - 5.0	0m - 5.1	0m - 5.3
14	0m - 4.7		0m - 5.0	0m - 5.2	0m - 5.3
15	1m - 4.7		1m - 5.0	.5m - 5.1	2m - 5.3
16		.75m - 4.8	1m - 4.9	1m - 5.0	1m - 5.3
17		0m - 5.8	2m - 5.0	2m - 5.1	1m - 5.3
18		1m - 4.5 2m - 4.5	0m - 4.7 0m - 4.7	0m - 4.8 0m - 4.9	0m - 5.0
19		0m - 4.5	0m - 4.7	0m - 4.9	0m - 5.0

SELENIUM

SAMPLING DATE

	July 12	August 2	August 23	September 24	October 25
Station 01	0m - <.1	0m - <.100	0m - <.100	0m - <.1	0m - <.1
02	0m - <.1	0m - <.100	0m - <.100	0m - <.1	0m - <.1
	2m - <.1	2m - <.100	3m - <.100	2m - <.1	5m - <.1
	3m - <.1	4m - <.100	4.5m - <.100	5m - <.1	11m - <.1
03	2.5m - <.1	2m - <.100	2.25m - <.100	2.25m - <.1	2.25m - <.1
04	1m - <.1	.6m - <.100	1m - <.100	.5m - <.1	.5m - <.1
05	3m - <.1	3m - <.100	3m - <.100	3m - <.1	3m - <.1
06	2m - <.1		2m - <.1	3m - <.01	3m - <.1
07	2.5m - <.1	2.5m - <.100	2.5 - <.100	2.5m - <.1	2.5m - <.1
	5m - <.1	5m - <.100	5m - <.100	4m - <.1	4m - <.1
	7m - <.1	8m - <.100	7.5m - <.100	7.5 - <.1	7.5m - <.1
08	0m - <.1		0m - <.100	0m - <.1	0m - <.1
09	2m - <.1	2m - <.100	2m - <.100	2m - <.1	2m - <.1
10	0m - <.1	0m - <.100	0m - <.100	0m - <.1	0m - <.1
11	1.5m - <.1		1.5m - <.100	1.5m - <.1	1.5m - <.1
12	0m - <.1	0m - <.100	0m - <.100	0m - <.1	0m - <.1
	2m - <.1	2m - <.100	2m - <.100	2m - <.1	2m - <.1
	4m - <.1	m - <.100	4m - <.100	4m - <.1	4m - <.1
13	0m - <.1		0m - <.100	0m - <.1	0m - <.1
14	0m - <.1		0m - <.100	0m - <.1	0m - <.1
15	1m - <.1		1m - <.100	.5m - <.1	2m - <.1
16		.75m - <.100	1m - <.100	1m - <.1	1m - <.1
17		0m - <.100	2m - <.100	2m - <.1	1m - <.1
18		1m - <.100	0m - <.100	0m - <.1	0m - <.1
		2m - <.100	0m - <.100	0m - <.1	
19		0m - <.100	0m - <.1	0m - <.1	0m - <.1

SULFATE

SAMPLING DATE

	July 12	August 3	August 23	September 24	October 25
		9.7			
Station 01	0m - 9.2	0m - 11.0	0m - 9.1	0m - 10.0	0m - 9.4
02	0m - 12.0	0m - 9.1	0m - 8.8	0m - 10.0	0m - 7.9
	2m - 8.6	2m - 11.0	3m - 8.8	2m - 7.7	5m - 7.9
	3m - 45.0	4m - 9.1	4.5m - 9.1	5m - 8.8	11m - 7.7
03	2.5m - 9.4	2m - 9.1	2.25m - 8.6	2.25m - 8.5	2.25m - 7.7
04	1m - 8.6	.6m - 9.1	1m - 8.6	.5m - 8.2	.5m - 7.2
05	3m - 9.4	3m - 9.1	3m - 8.6	3m - 7.7	3m - 7.7
06	2m - 9.8		2m - 9.3	3m - 8.8	3m - 7.7
07	2.5m - 8.6	2.5m - 10.0	2.5 - 8.8	2.5m - 8.0	2.5m - 6.9
	5m - 11.0	5m - 9.7	5m - 8.8	4m - 8.0	4m - 7.2
	7m - 12.0	8m - 11.0	7.5m - 9.1	7.5 - 8.8	7.5m - 7.1
08	0m - 5.8		0m - 9.1	0m - 7.7	0m - 7.1
09	2m - 8.9	2m - 9.1	2m - 8.6	2m - 8.5	2m - 7.2
10	0m - 8.0	0m - 9.1	0m - 9.3	0m - 8.2	0m - 7.1
11	1.5m - 8.6		0m - 9.1	1.5m - 8.0	1.5m - 7.9
12	0m - 11.0	0m - 11.0	0m - 8.6	0m - 8.8	0m - 7.1
	2m - 8.0	2m - 9.7	2m - 8.6	2m - 8.2	2m - 6.9
	4m - 11.0	4m - 10.0	4m - 9.1	4m - 8.0	4m - 6.3
13	0m - 7.5		0m - 8.6	0m - 8.0	0m - 6.6
14	0m - 8.3		0m - 8.8	0m - 8.2	0m - 7.7
15	1m - 10.0		1m - 9.7	.5m - 8.0	2m - 7.2
16		.75m - 9.5	1m - 9.7	1m - 8.8	1m - 7.9
17		2m - 10.0	2m - 8.4	2m - 8.2	1m - 7.9
18		1m - 11.0	0m - 8.4	0m - 9.3	0m - 8.3
		2m - 10.0	0m - 8.6	0m - 8.5	
19		0m - 11.0	0m - 8.1	0m - 8.8	0m - 7.9

SUSPENDED SOLIDS — SAMPLING DATE

	July 12	August 2	August 23	September 24	October 25
Station 01	0m - 2.0	0m - 0.80 0.50	0m - 2.4	0m - .80	0m - 1.3
02	0m - 08.0 2m - 03.0 3m - 1.00	0m - 1.30 2m - 0.30 4m - 1.80	0m - 0.8 3m - 0.8 4.5m - 1.2	0m - .500 2m - 2.3 5m - 3.0	0m - 0.8 5m - 0.8 11m - 6.8
03	2.5m - 0.30	2.0m - 2.00	2.25m - 25.2	2.25m - 1.0	2.25m - 1.0
04	1m - 1.30	.6m - 1.80	1m - 3.2	.5m - 1.5	.5m - 34.8
05	3m - 1.30	3m - 0.80	3m - 2.4	3m - 1.0	3m - .50
06	2m - 0.50		2m - 0.8	3m - 1.3	3m - .50
07	2.5m - 0.30 5m - 0.30 7m - 0.80	2.5m - 0.50 5m - 1.00 8m - 5.80	2.5 - 1.6 5m - 0.8 7.5m - 15.2	2.5m - 1.5 4m - 1.3 7.5 - 4.0	2.5m - .30 4m - .30 7.5m - 3.0
08	0m - 0.30		0m - 0.4	0m - 4.3	0m - 1.0
09	2m - 0.30	2m - 0.8	2m - 2.4	2m - 7.5	2m - 1.3
10	0m - 1.00	0m - 1.0	0m - 2.0	0m - 1.3	0m - .30
11	1.5m - 1.30		0m - 0.4	1.5m - 1.5	1.5m - .50
12	0m - 1.00 2m - 0.30 4m - 3.00	0m - 0.8 2m - 0.5 4m - 1.0	0m - 1.2 2m - 1.6 4m - 1.6	0m - 0.3 2m - 1.0 4m - .5	0m - 0.8 2m - 0.3 4m - 1.3
13	0m - 0.50		0m - 1.2	0m - .3	0m - 1.8
14	0m - 0.80		0m - 1.2	0m - .3	0m - 1.3
15	1m - 0.30		1m - 0.4	.5m - .3	2m - 1.8
16		.75m - 1.0	1m - 1.6	1m - .3	1m - .5
17		0m - 1.0	2m - 0.8	2m - 1.3	1m - .3
18		1m - 1.5 2m - 12.8	0m - 0.4 0m - 1.2	0m - 3.8 0m - 1.5	0m - 3.5
19		0m - 0.8	0m - 0.4	0m - 1.3	0m - .8

RON (mg/1)

SAMPLING DATE

	July 12	August 3	August 23	September 24	October 25
Station 01	0m - .188	0m - .16,.15	0m - .229	0m - .152	0m - .14
02	0m - .216	0m - .2	0m - .196	0m - .229	0m - .224
	2m - .223	2m - .18	3m - .200	2m - .180	5m - .268
	3m - .230	4m - .33	4.5m - .653	5.0m - .249	11m - .390
03	2.5m - .236	2m - .23	2.25m - .406	2.25m - .220	2.25m - .304
04	1m - .244	6m - .17	1m - .221	.5m - .214	.5m - .549
05	3m - .177	3m - .17	3m - .227	3m - .380	3m - .202
06	2m - .155		2m - .126	3m - .275	3m - .202
07	2.5m - .165	2.5m - .15	2.5 - .130	2.5m - .267	2.5m - .203
	5m - .156	5m - .16	5m - .158	4m - .227	4m - .203
	7m - .168	8m - 1.0	7.5m - .052	7.5 - .304	7.5m - .279
08	0m - .157		0m - .131	0m - .327	0m - .230
09	2m - .199	2m - .16	2m - .149	2m - .312	2m - .213
10	0m - .168	0m - .16	0m - .130	0m - .212	0m - .425
11	1.5m - .186		0m - .164	1.5m - .182	1.5m - .215
12	0m - .176	0m - .15	0m - .141	0m - .158	0m - .165
	2m - .172	2m - .15	2m - .152	2m - .153	2m - .163
	4m - .197	4m - .17	4m - .192	4m - .16	4m - .166
13	0m - .204		0m - .126	0m - .144	0m - .220
14	0m - .208		0m - .181	0m - .137	0m - .204
15	1m - .159		0m - .139	.5m - .139	2m - .175
16		.74m - .17	1m - .169	1m - .213	1m - .220
17		2m - .17	2m - .204	2m - .220	1m - .238
18		1m - .17	0m - .137	0m - .123	0m - .131
		2m - .21	0m - .135	0m - .117	
19		0m - .10	0m - .118	0m - .061	0m - .059

MANGANESE

SAMPLING DATE

	July 12	August 3	August 23	September 24	October 25
Station 01	0m - .114	0m - .114,.109	0m - .115	0m - .147	0m - .124
02	0m - .135	0m - .161	0m - .158	0m - .157	0m - .140
	2m - .136	2m - .163	3m - .155	2m - .131	5m - .143
	3m - .146	4m - .154	4.5m - .190	5m - .141	11m - .147
03	2.5m - .140	2m - .172	2.25m - .171	2.25m - .172	2.25m - .162
04	1m - .195	6m - .164	1m - .177	.5m - .160	.5m - .162
05	3m - .156	3m - .174	3m - .179	3m - .272	3m - .135
06	2m - .152		2m - .178	3m - .186	3m - .138
07	2.5m - .159	2.5m - .164	2.5 - .178	2.5m - .177	2.5m - .148
	5m - .159	5m - .174	5m - .178	4m - .147	4m - .144
	7m - .149	8m - .136	7.5m - .175	7.5 - .150	7.5m - .147
08	0m - .167		0m - .200	0m - .193	0m - .182
09	2m - .166	2m - .192	2m - .199	2m - .192	2m - .149
10	- .184	0m - .197	0m - .194	0m - .204	0m - .144
11	1.5m - .193		1.5m - .200	1.5m - .158	1.5m - .146
12	0m - .226	0m - .201	0m - .213	0m - .168	0m - .142
	2m - .196	2m - .206	2m - .210	2m - .168	2m - .149
	4m - .192	4m - .209	4m - .219	4m - .170	4m - .153
13	0m - .225		0m - .220	0m - .166	0m - .119
14	0m - .202		0m - .224	0m - .196	0m - .149
15	1m - .193		1m - .206	.5m - .166	2m - .142
16		.74m - .171	1m - .177	1m - .141	1m - .138
17		2m - .156	2m - .177	2m - .141	1m - .139
18		1m - .113	0m - .120	0m - .121	0m - .127
		2m - .112	0m - .117	0m - .120	
19		0m - .120	0m - .112	0m - .129	0m - .118

TIN

SAMPLING DATE

	July 12	August 2	August 23	September 24	October 25
		< .03			
Station 01	0m - <03	0m - < .03	0m - <03	0m - < .03	0m - < .03
02	0m - <03	0m - < .03	0m - <03	0m - < .03	0m - < .03
	2m - <03	2m - < .03	3m - <03	2m - < .03	5m - < .03
		4m - < .03	4.5m - <03	5m - < .03	11m - < .03
03	2m - <03	2m - < .03	2.25m - <03	2.25m - < .03	2.25m - < .03
04	.6m - <03	.6m - < .03	1m - <03	.5m - < .03	.5m - < .03
05	3m - <03	3m - < .03	3m - ≤03	3m - < .03	3m - < .03
06	0m - ≤03		2m - ≤03	3m - < .03	3m - < .03
07	2.5m - ≤03	2.5m - < .03	2.5 - ≤03	2.5m - < .03	2.5m - < .03
	5m - ≤03	5m - < .03	5m - ≤03	4m - < .03	4m - < .03
	8m - ≤03	8m - < .03	7.5m - ≤03	7.5 - < .03	7.5m - < .03
08	0m - <03		0m - ≤03	0m - < .03	0m - < .03
09	2m - ≤03	2m - < .03	2m - ≤03	2m - < .03	2m - < .03
10	0m - ≤03	0m - < .03	0m - ≤03	0m - < .03	0m - < .03
11	1.5m - ≤03		1.5m - ≤03	1.5m - < .03	1.5m - < .03
12	0m - <03	0m - < .03	0m - ≤03	0m - < .03	0m - < .03
	2m - <03	2m - < .03	2m - ≤03	2m - .01	2m - < .03
	4m - <03	4m - < .03	4m - ≤03	4m - .01	4m - < .03
13	0m - ≤03		0m - ≤03	0m - < .03	0m - < .03
14	0m - ≤03		0m - ≤03	0m - < .03	0m - < .03
15	0m - ≤03		1m - ≤03	.5m - < .03	2m - < .03
16		.75m - < .03	1m - ≤03	1m - < .03	1m - < .03
17		0m - < .03	2m - ≤03	2m - < .03	1m - < .03
18		1m - < .03	0m - ≤03	0m - < .03	0m - < .03
		2m - < .03	0m - <03	0m - < .03	
19		0m - < .03	0m - ≤03	0m - < .03	0m - < .03

TOTAL DISSOLVED SOLIDS — SAMPLING DATE

	July 12	August 3	August 23	September 24	October 25
		34.0			
Station 01	0m - 32.0	0m - 42.0	0m - 37.0	0m - 38.0	0m - 27.0
02	0m - 28.0	0m - 37.0	0m - 34.0	0m - 38.0	0m - 23.0
	2m - 34.0	2m - 42.0	3m - 39.0	2m - 31.0	5m - 27.0
	3m - 44.0	4m - 41.1	4.5m - 45.0	5m - 31.0	11m - 27.0
03	2.5m - 35.0	2m - 34.0	2.25m - 41.0	2.25m - 36.0	2.25m - 30.0
04	1m - 32.0	.6m - 33.0	1m - 32.0	.5m - 33.0	.5m - 28.0
05	3m - 32.0	3m - 32.0	3m - 32.0	3m - 35.0	3m - 21.0
06	2m - 30.0		- 26.0	3m - 35.0	3m - 19.0
07	2.5m - 31.0	2.5m - 39.0	2.5 - 25.0	2.5m - 35.0	2.5m - 20.0
	5m - 30.0	5m - 42.0	5m - 34.0	4m - 34.0	4m - 20.0
	7m - 31.0	8m - 38.0	7.5m - 29.0	7.5 - 33.0	7.5m - 20.0
08	0m - 27.0		0m - 31.0	0m - 42.0	0m - 32.0
09	2m - 33.0	2m - 40.0	2m - 31.0	2m - 37.0	2m - 22.0
10	0m - 32.0	0m - 42.0	0m - 30.0	0m - 36.0	0m - 21.0
11	1.5m - 32.0		1.5m - 27.0	1.5m - 36.0	1.5m - 22.0
12	0m - 36.0	0m - 34.0	0m - 30.0	0m - 34.0	0m - 20.0
	2m - 28.0	2m - 38.0	2m - 34.0	2m - 34.0	2m - 21.0
	4m - 49.0	4m - 27.0	4m - 28.0	4m - 32.0	4m - 22.0
13	0m - 24.0		0m - 28.0	0m - 34.0	0m - 22.0
14	0m - 32.0		0m - 23.0	0m - 34.0	0m - 22.0
15	1m - 33.0		1m - 25.0	.5m - 32.0	2m - 24.0
16		.75m - 33.0	1m - 36.0	1m - 35.0	1m - 20.0
17		2m - 33.0	2m - 37.0	2m - 34.0	1m - 18.0
18		1m - 39.0	0m - 29.0	0m - 32.0	0m - 17.0
		2m - 30.0	0m - 33.0	0m - 31.0	
19		0m - 36.0	0m - 32.0	0m - 31.0	0m - 15.0

TOTAL NITROGEN

SAMPLING DATE

	July 12	August 3	August 23	September 24	October 25
		.16			
Station 01	0m - .24	0m - .19	0m - .16	0m - .14	0m - .16
02	0m - .20	0m - .18	0m - .13	0m - .17	0m - .37
	2m - .20	2m - .15	3m - .23	2m - .19	5m - .20
	3m - .21	4m - .26	4.5m - .30	5m - .20	11m - .25
03	2.5m - .19	2m - .17	2.25m - .14	2.25m - .17	2.25m - .32
04	1m - .18	.6m - .15	1m - .14	.5m - .18	.5m - .25
05	3m - .17	3m - .18	3m - .13	3m - .20	3m - .25
06	2m - .15		2m - .15	3m - .22	3m - .22
07	2.5m - .22	2.5m - .34	2.5 - .16	2.5m - .19	2.5m - .28
	5m - .18	5m - .21	5m - .15	4m - .19	4m - .23
	7m - .21	8m - .34	7.5m - .28	7.5 - .20	7.5m - .22
08	0m - .18		0m - .13	0m - .17	0m - .27
09	2m - .16	2m - .16	2m - .12	2m - .17	2m - .20
10	0m - .23	0m - .17	0m - .12	0m - .16	0m - .18
11	1.5m - .20		0m - .12	1.5m - .17	1.5m - .23
12	0m - .26	0m - .14	0m - .11	0m - .15	0m - .18
	2m - .15	2m - .17	2m - .11	2m - .18	2m - .19
	4m - 1.5	4m - .15	4m - .17	4m - .17	4m - .18
13	0m - .23		0m - .10	0m - .14	0m - .19
14	0m - .14		0m - .10	0m - .14	0m - .19
15	1m - .16		1m - .11	.5m - .17	2m - .23
16		.75m - .17	1m - .13	1m - .18	1m - .26
17		0m - .18	2m - .14	2m - .23	1m - .29
18		1m - .17	0m - .17	0m - .15	0m - .14
		2m - .15	0m - .15	0m - .15	
19		0m - .16	0m - .13	0m - .13	0m - .16

TOTAL ORGANIC CARBON — SAMPLING DATE

	July 12	August 3	August 23	September 24	October 25
		2.9			
Station 01	0m - 4.0	0m - 3.2	0m - 4.0	0m - 4.6	0m - < .5
02	0m - 3.6	0m - 2.8	0m - 2.1	0m - 4.2	0m - 2.9
	2m - 3.4	2m - 2.8	3m - 2.6	2m - 4.1	5m - 2.9
	3m - 4.0	4m - 3.1	4.5m - 3.0	5m - 4.2	11m - 2.9
03	2.5m - 3.4	2m - 3.1	2.25m - 2.6	2.25m - 4.0	2.25m - 2.9
04	1m - 3.3	.6m - 2.9	1m - 2.1	.5m - 3.8	.5m - 2.9
05	3m - 3.1	3m - 2.8	3m - 1.8	3m - 3.5	3m - 2.6
06	2m - 3.1		2m - 1.8	3m - 3.4	3m - 2.5
07	2.5m - 3.3	2.5m - 2.8	2.5 - 1.8	2.5m - 3.2	2.5m - 2.5
	5m - 3.3	5m - 2.5	5m - 1.6	4m - 3.6	4m - 2.5
	7m - 3.3	8m - 4.0	7.5m - 3.2	7.5 - 3.6	7.5m - 2.5
08	0m - 3.1		0m - 2.1	0m - 3.6	0m - 7.8
09	2m - 3.1	2m - 2.5	2m - 1.4	2m - 3.0	2m - 2.6
10	0m - 3.3	0m - 2.3	0m - 1.6	0m - 2.6	0m - 2.1
11	1.5m - 3.1		0m - 1.8	1.5m - 3.1	1.5m - 2.3
12	0m - 3.1	0m - 1.8	0m - 1.6	0m - 2.6	0m - 1.7
	2m - 3.1	2m - 2.2	2m - 1.4	2m - 2.9	2m - 1.9
	4m - 3.1	4m - 2.5	4m - 1.6	4m - 2.9	4m - 1.7
13	0m - 3.3		0m - 1.6	0m - 2.5	0m - 2.7
14	0m - 3.3		0m - 1.6	0m - 2.6	0m - 2.1
15	1m - 2.9		1m - 1.6	.5m - 2.6	2m - 2.0
16		.75m - 2.8	1m - 1.6	1m - 3.4	1m - 2.7
17		0m - 2.8	2m - 1.8	2m - 3.8	1m - 2.7
18		1m - 3.1	0m - 3.4	0m - 4.3	0m - 3.1
		2m - 3.2	0m - 3.2	0m - 4.2	
19		0m - 2.6	0m - 3.2	0m - 3.4	0m - 3.4

TOTAL PHOSPHATE — SAMPLING DATE

	July 12	August 3	August 23	September 24	October 25
		.04			
Station 01	0m - .08	0m - .04	0m - .02	0m - .04	0m - .04
02	0m - <.02	0m - .06	0m - .02	0m - .03	0m - .06
	2m - .03	2m - .04	3m - .03	2m - .02	5m - .05
	3m - .07	4m - .05	4.5m - .03	5m - .02	11m - .14
03	2.5m - .03	2m - .05	2.25m - .06	2.25m - .07	2.25m - .12
04	1m - .05	.6m - .05	1m - .02	.5m - .21	.5m - .44
05	3m - .06	3m - .05	3m - .02	3m - .13	3m - .08
06	2m - .03		2m - .03	3m - .03	3m - .04
07	2.5m - .03	2.5m - .03	2.5 - .02	2.5m - .06	2.5m - .11
	5m - .03	5m - .04	5m - <.02	4m - <.02	4m - .05
	7m - .06	8m - .08	7.5m - .05	7.5 - .05	7.5m - .06
08	0m - .02		0m - <.02	0m - .03	0m - .05
09	2m - .03	2m - .04	2m - <.02	2m - .10	2m - .05
10	0m - .06	0m - .04	0m - .02	0m - .05	0m - .05
11	1.5m - .04		1.5m - .03	1.5m - .06	1.5m - .08
12	0m - .03	0m - .03	0m - <.02	0m - .02	0m - .06
	2m - .05	2m - .08	2m - .02	2m - .04	2m - .11
	4m - .04	4m - .06	4m - .02	4m - .02	4m - .06
13	0m - .03		0m - .02	0m - .02	0m - .05
14	0m - .05		0m - .03	0m - .04	0m - .06
15	1m - .04		1m - <.02	.5m - .02	2m - .06
16		.75m - .05	1m - <.02	1m - <.02	1m - .1
17		2m - .04	2m - .03	2m - .03	1m - .05
18		1m - .04	0m - <.02	0m - <.02	0m - .05
		2m - .12	0m - .02	0m - <.02	
19		0m - .04	0m - .02	0m - .03	0m - .0

TURBIDITY

SAMPLING DATE

	July 12	August 3	August 23	September 24	October 25
Station 01	0m - 7.7	0m - 1.2 .98	0m - 1.1	0m - .80	0m - 1.2
02	0m - 1.1 2m - 1.2 3m - 1.1	0m - .91 2m - .91 4m - 1.7	0m - 1.2 3m - 1.2 4.5m - 2.6	0m - 1.1 2m - 1.2 5m - 1.5	0m - 1.3 5m - 1.5 11m - 2.9
03	2.5m - 1.5	2.0m - 1.2	2.25m - 4.1	2.25m - 1.3	2.25m - 1.4
04	1m - 1.3	.6m - 1.4	1m - 1.5	.5m - 1.3	.5m - 4.3
05	3m - 1.1	3m - 1.5	3m - .64	3m - 1.1	3m - .90
06	2m - 1.0		2m - .61	3m - 1.1	3m - 1.0
07	2.5m - 1.1 5m - .92 7m - 1.0	2.5m - .99 5m - 1.2 8m - 3.1	2.5 - .64 5m - 1.2 7.5m - 4.5	2.5m - 1.2 4m - 1.3 7.5 - 1.5	2.5m - 1.3 4m - 1.1 7.5m - 1.5
08	0m - 8.6		0m - .63	0m - 1.3	0m - 1.0
09	2m - 1.3	2m - .71	2m - .63	2m - 1.5	2m - 1.8
10	0m - 1.2	0m - .68	0m - .60	0m - .67	0m - .79
11	1.5m - .87		1.5m - .82	1.5m - .95	1.5m - 1.1
12	0m - .92 2m - .79 4m - 1.2	0m - .67 2m - 1.1 4m - 1.1	0m - .78 2m - .75 4m - 1.00	0m - .76 2m - .77 4m - .81	0m - .76 2m - .57 4m - .77
13	0m - .82		0m - .73	0m - .74	0m - 1.1
14	0m - .86		0m - 1.00	0m - .85	0m - 1.1
15	- 1.1		1m - .82	.5m - .68	2m - 1.0
16		.75m - 1.2	1m - 1.00	1m - 1.1	1m - 1.4
17		0m - .81	2m - 1.30	2m - 1.2	1m - 1.1
18		1m - .82 2m - 2.1	0m - .80 0m - .60	0m - 1.5 0m - .85	0m - 1.0
19		0m - .55	0m - .52	0m - .57	0m - .52

VANADIUM

SAMPLING DATE

	July 12	August 2	August 23	September 24	October 25
		<.01			
Station 01	0m - <.01	0m - <.01	0m - <.01	0m - <.01	0m - <.01
02	0m - <.01	0m - <.01	0m - <.01	0m - <.01	0m - <.01
	2m - <.01	2m - <.01	3m - <.01	2m - <.01	5m - <.01
	3m - <.01	4m - <.01	4.5m - <.01	5m - <.01	11m - <.01
03	2.5m - <.01	2m - <.01	2.25m - <.01	2.25m - <.01	2.25m - <.01
04	1m - <.01	.6m - <.01	1m - <.01	.5m - <.01	.5m - <.01
05	3m - <.01	3m - <.01	3m - <.01	3m - <.01	3m - <.01
06	2m - <.01		2m - <.01	3m - <.01	3m - <.01
07	2.5m - <.01	2.5m - <.01	2.5 - <.01	2.5m - <.01	2.5m - <.01
	5m - <.01	5m - <.01	5m - <.01	4m - <.01	4m - <.01
	7m - <.01	8m - <.01	7.5m - <.01	7.5 - <.01	7.5m - <.01
08	0m - <.01		0m - <.01	0m - <.01	0m - <.01
09	2m - <.01	2m - <.01	2m - <.01	2m - <.01	2m - <.01
10	0m - .01	0m - <.01	0m - <.01	0m - .01	0m - <.01
11	1.5m - <.01		1.5m - <.01	1.5m - <.01	1.5m - <.01
12	0m - <.01	0m - <.01	0m - <.01	0m - <.01	0m - <.01
	2m - <.01	2m - <.01	2m - <.01	2m - .01	2m - <.01
	4m - <.01	4m - <.01	4m - <.01	4m - .01	4m - <.01
13	0m - <.01		0m - <.01	0m - <.01	0m - <.01
14	0m - <.01		0m - <.01	0m - <.01	0m - <.01
15	1m - <.01		1m - <.01	.5m - <.01	2m - <.01
16		.75m - <.01	1m - <.01	1m - <.01	1m - <.01
17		0m - <.01	2m - <.01	2m - <.01	1m - <.01
18		1m - <.01	0m - <.01	0m - <.01	0m - <.01
		2m - <.01	0m - <.01	0m - <.01	
19		0m - <.01	0m - <.01	0m - <.01	0m - <.01

ZINC

SAMPLING DATE

	July 12	August 2	August 23	September 24	October 25
Station 01	0m - .02	0m - < .01	0m - .02	0m - .01	0m - < .01
02	0m - .01	0m - .01	0m - .01	0m - .01	0m - .01
	2m - .02	2m - .15	3m - .02	2m - .01	5m - .01
	3m - .01	4m - < .01	4.5m - .01	5m - .01	11m - .01
03	2.5m - .01	2m - < .01	2.25m - .01	2.25m - .02	2.25m - .01
04	1m - .02	.6m - < .01	1m - .01	.5m - .02	.5m - .01
05	3m - .01	3m - .02	3m - .02	3m - .03	3m - < .01
06	2m - .02		2m - .01	3m - .02	3m - .01
07	2.5m - .02	2.5m - .14	2.5 - .05	2.5m - .02	2.5m - .01
	5m - .02	5m - < .01	5m - .01	4m - <.01	4m - .02
	7m - .02	8m - .06	7.5m - .02	7.5 - .01	7.5m - .01
08	0m - .02		0m - .01	0m - .02	0m - < .01
09	2m - .01	2m - .02	2m - .01	2m - .01	2m - .01
10	0m - .02	0m - < .01	0m - .01	0m - .02	0m - .02
11	1.5m - .02		- .02	1.5m - .01	1.5m - < .01
12	0m - .03	0m - .09	0m - .01	0m - .01	0m - .01
	2m - .01	2m - < .01	2m - .02	2m - .01	2m - .01
	4m - .02	m - .08	4m - .02	4m - .01	4m - < .01
13	0m - .02		0m - .01	0m - .01	0m - .01
14	0m - .02		0m - < .01	0m - .01	0m - .01
15	1m - .01		1m - .01	.5m - <.01	2m - .01
16		.75m - < .01	1m - .01	1m - <.01	1m - < .01
17		0m - < .01	2m - .01	2m - <.01	1m - .01
18		1m - < .01	0m - < .01	0m - <.01	0m - < .01
		2m - .06	0m - < .01	0m - <.01	
19		0m - < .01	0m - < .01	0m - .01	0m - .01

DISSOLVED OXYGEN AND TEMPERATURE

	July 12			August 3			August 23			September 25			October 25		
Station	Depth	Temp. °C	D.O.	Depth	Temp. °C	D.O.	Depth	Temp. °C	D.O.	Depth	Temp. °C	D.O.	Depth	Temp. °C	D.O
01										0m	8.8	17°	0m	10.5	9.6
02				0m	24.0	8.2	0m	23.0	8.2	0m	9.4	18.5	0m	11.0	9.3
				1m	24.0	8.0	1m	23.0	8.2	1m	10.0	18.5	1m	11.0	9.3
				2m	23.0	8.0	2m	23.0	8.2	2m	11.0	18.5	2m	11.0	8.8
													3m	10.8	8.8
				3m	22.0	7.5	3m	23.0	8.2	3m	12.0	18.0	4m	10.5	8.4
													5m	10.0	8.9
				4m	19.5	4.3	4m	23.0	8.0	4m	12.9	18.0	6m	10.0	8.5
													7m	9.8	8.6
				5m	16.0		5m	21.0	5.6				8m	9.8	8.5
03							6m	18.0	0	0m	17.0	8.4	0m	11.0	8.8
										1m	16.8	8.3	1m	11.0	8.7
										2m	16.2	8.1	2m	10.7	8.2
04										0m	17.0	8.7	0m	11.0	8.8
										.5m	17.0	8.5			
05										0m	16.9	8.4	0m	11.5	9.3
										1m	16.9	8.3	1m	11.4	9.3
										2m	16.7	8.2	2m	11.3	9.4
										3m	16.5	8.2	3m	11.3	9.3
										4m	16.5	8.1			
										5m	16.2	7.9			
										6m	16.2	6.7			
06										0m	17.0	8.5	0m	11.5	9.4
										1m	17.0	8.4	1m	11.3	9.4
										2m	16.8	8.3	2m	11.2	9.3
										3m	16.8	8.2	3m	11.2	9.3
													4m	11.1	9.1
										4m	16.5	8.0	5m	11.0	8.7
07				0m	24.0	8.2	0m	23.0	8.2	0m	17.0	8.5	0m	11.2	9.5
				1m	23.0	8.2	1m	22.5	8.2	1m	17.0	8.4	1m	11.2	9.5
				2m	23.0	8.2	2m	22.5	8.0	2m	17.0	8.4	2m	11.2	9.5
				3m	22.5	8.2	3m	22.5	8.0	3m	17.0	8.2	3m	11.1	9.4

DISSOLVED OXYGEN AND TEMPERATURE (con't)

	July 12			August 3			August 23			September 25			October 25		
Station	Depth	Temp. °C	D.O.	Depth	Temp. °C	D.O.	Depth	Temp. °C	D.O.	Depth	Temp. °C	D.O.	Depth	Temp. °C	D.O
				4m	22.0	7.7	4m	22.5	8.0	4m	16.8	8.2	4m	11.1	9.3
				5m	21.0	7.6	5m	22.0	8.0	5m	16.5	8.0	5m	11.1	9.3
				6m	19.0	5.8	6m	21.5	7.4	6m	16.3	7.6	6m	11.1	9.2
							6.5m		3.0						
				7m	16.0	4.3	7m	17.5	2.8	7m	16.0	7.6	7m	10.9	9.0
				8m	15.0	3.0				7.5m	16.0	7.7	8m	10.9	8.7
				9m	14.0	2.0									
08										0m	15.5	9.1	0m	10.8	9.4
09										0m	17.0	8.5	0m	11.5	9.4
										1m	17.0	8.3	1m	11.4	9.3
										2m	16.8	8.3	2m	11.2	9.4
10										0m	16.5	8.6	0m	11.3	9.3
										1m	16.5	8.6	1m	11.2	9.3
										2m	16.5	8.6	2m	11.2	9.2
										3m	16.2	8.6	3m	11.2	9.1
										4m	16.2	8.6	4m	11.1	8.7
11										0m	17.2	8.5	0m	11.2	9.2
										1m	17.2	8.4	1m	11.2	9.2
										2m	17.0	8.3	2m	11.2	9.2
										3m	16.5	8.1	3m	11.2	9.2
12				0m	23.5	8.7	0m	23.0	8.8	0m	16.7	8.6	0m	11.1	9.5
				1m	23.0	8.5	1m	23.0	8.6	1m	16.7	8.5	1m	11.1	9.5
				2m	22.5	8.2	2m	23.0	8.6	2m	16.7	8.4	2m	11.1	9.6
				3m	22.0	8.4	3m	23.0	8.6	3m	16.5	8.3	3m	11.1	9.5
				4m	22.0	8.6	4m	22.0	8.4	4m	16.5	8.1	4m	11.1	9.5
							5m	22.0	7.6	5m	16.2	8.0	5m	11.1	9.3
13										0m	17.0	8.7	0m	11.5	9.5
										1m	17.0	8.7	1m	11.4	9.6
14										0m	17.5	8.6	0m	11.5	9.5
										1m	17.5	8.5	1m	11.3	9.4
													2m	10.9	9.2

DISSOLVED OXYGEN AND TEMPERATURE (con't)

	July 12			August 3			August 23			September 25			October 25		
Station	Depth	Temp. °C	D.O.	Depth	Temp. °C	D.O.	Depth	Temp. °C	D.O.	Depth	Temp. °C	D.O.	Depth	Temp. °C	D.O
15										0m	16.8	8.6	0m	11.0	9.4
										1m	16.8	8.6	1m	11.0	9.4
										2m	16.8	8.6	2m	11.0	9.0
										3m	16.8	8.5	3m	10.9	8.9
16				0m	24.0	9.3	0m	23.0	9.6	0m	17.0	8.5	0m	11.3	9.1
				1m	23.5	9.2	1m	22.5	9.4	1m	17.0	8.4	1m	11.1	9.0
				2m	22.5	9.0	2m	22.5	9.0	2m	16.8	8.5	2m	11.0	9.1
							3m	22.0	8.6						
				3m	21.5	8.2	4m	22.0	8.4						
							5m	21.0	4.8						
				4m	21.0	6.6	6m	19.0	0						
17							0m	23.0	8.2	0m	17.0	8.3	0m	11.9	9.5
							1m	23.0	8.2	1m	16.9	7.8	1m	11.8	9.5
							2m	23.0	8.2	2m	16.5	8.1	2m	11.8	9.4
							3m	23.0	8.2	3m	16.2	7.7	3m	11.8	9.4
							4m	22.0	0	4m	16.0	7.2			
18										0m	18.5	9.6	0m		10.
19										0m	17.5	9.4	0m		10.

ORTHRO - PHOSPHATE PO_4 - AVERAGE VALUES AT EACH MEASURED DEPTH
FOR JULY - OCTOBER 1984

STATION	DEPTH	$\bar{x}$ [PO_4]	NUMBER DETERMINATIONS
01	0m	.03	6
02	0m	<.02	5
	2m	<.02	3
	3m	<.02	2
	4m	<.02	1
	4.5m	.03	1
	5m	<.02	2
	11m	<.02	1
03	2m	<.02	1
	2.25m	<.02	4
04	.5m	.07	2
	.6m	<.02	1
	1m	<.02	2
05	3m	<.02	5
06	2m	<.02	2
	3m	<.02	2
07	2.5m	<.02	5
	4m	<.02	2
	5m	<.02	3
	7m	<.02	1
	7.5m	<.02	3
	8m	<.02	1
08	0m	<.02	4
09	2m	<.02	5
10	0m	<.02	5
11	1.5m	<.02	4
12	0m	<.02	5
	2m	.03	5
	4m	<.02	5
13	0m	<.02	4
14	0m	<.02	4
15	0m	<.02	1
	.5m	<.02	1
	1m	<.02	1
	2m	.03	1
16	.75m	<.02	1
	1m	.03	3
17	1m	.05	1
	2m	<.02	3
18	0m	<.02	5
	1m	<.02	1
	2m	<.02	1
19	0m	<.02	4

TOTAL - PHOSPHATE PO_4 - AVERAGE VALUES AT EACH MEASURED DEPTH
FOR JULY - OCTOBER 1984

STATION	DEPTH	$\bar{x}$ $[PO_4]$	NUMBER DETERMINATIONS
01	0m	.04	6
02	0m	.04	5
	2m	.03	3
	3m	.05	2
	4m	.05	1
	4.5m	.03	1
	5m	.04	2
			1
03	2m	.05	1
	2.25m	.07	4
04	.5m		
	.6m	.05	1
	1m	.04	2
05	1m	.07	5
06	2m	.03	2
	3m	.03	2
07	2.5m	<.05	5
	4m	<.04	2
	5m	<.03	3
	7m	.06	1
	7.5m	.05	3
	8m	.08	1
08	0m	<.03	4
09	2m	.05	5
10	0m	.04	5
11	1.5m	.05	4
12	0m	<.03	5
	2m	.06	5
	4m	.04	5
13	0m	.02	4
14	0m	.05	4
15	0m	.04	1
	.5m	.02	1
	1m	<.02	1
	2m	.06	1
16	.75m	.05	1
	1m	<.06	3
17	1m	.045	1
	2m	.03	3
18	0m	<.03	5
	1m	.04	1
	2m	.12	1
19	0m	.03	4

	LAKE ECHO 1984		DEPARTMENT OF HEALTH Drinking Water Standards (1978)		N.S. LAKE VALUES or HALIFAX COUNTY PRISTINE LAKES* (1984)	
	Average	Range	Maximum	Objective	Average	Range
Alkalinity	<1.0-1.0 (mg/l)	<1.0-10	----	----	.65	<.1-1.5
Ammonia	<.05 (mg/l)	<.05-.14	----	----	.007*	0-.026
Antimony	<.05 (mg/l)	<.05	----	≤.0002	----	----
Arsenic	<.05 (mg/l)	<.05	.05	<.005	<.002	----
Chloride	5.75 (mg/l)	4-12	----	250.	10.28*	3.4-28.5
Chlorophyll a	7. (mg.l)	6.1-9.3	----	250.	----	----
Color	8. (TCU)	10-55	15 (TCU)	<15	45	7.5-200.
Conductivity	45.9 (umho/cm)	39-71	----	----	62.5*	24-150
			(Acceptable Range)			
Hardness	7.6 (mg/l)	6.1-9.3	80-100		6.01	3.99-9.42
Keldahl-N	.19 (mg/l)	.1-1.5	----	----	----	----
			10 (mg/l)(NO_2-NO_3)		----	----
Nitrate-Nitrite	<.05 (mg/l)	<.05-1.06	1 (mg/l)(NO_2)	<.001	.02*	0-.046
			10 (mg/l)(NO_3)			
Ortho-PO_4 (as PO_4)	<.02 (mg/l)	<.02-.07	----	----	<.001	<.001
			(Acceptable Range)			
pH	4.89 (units)	4.5-5.4	6.5-8.5		4.9	4.3-5.5
Susp. Solid	2.04 (mg/l)	.3-34.8	----	----	3	----
Sulfate	9.35 (mg/l)	5.8-12.0	500.	<150.	5.9*	3.0-11.8
Total diss. solid	31.4 (mg/l)	15-49	500.	----	20.	12.4-86.1
Total N	.19 (mg/l)	.1-1.5	----	----	.194*	.04-.42
Total org. C.	2.87 (mg/l)	<.5-7.8	----	----	8	.7-20.
Total - PO_4 (as PO_4)	20 (ug/l)	<20-44	----	----	4	<1-17.
Turbidity	1.33 (JTU)	.52-7.7	5 (NTU)	<1.	.92 (JTU)	.54-2.7
METALS						
Aluminum	.2 (mg/l)	.1-.35	0.1	----	.145	.008-.55
Barium	.007 (mg/l)	.005-.009	1.0	≤ 0.1	.024	.005-.084
Beryllium	< .005 (mg/l)	<.005	----	----	----	----
Boron	< .02 (mg/l)	<.02	5.0	≤ .01	----	----
Cadmium	.003 (mg/l)	.002-.007	.003	.002-.007	<.002	<.005-.008
Chromium	< .01 (mg/l)	<.01	.05	≤ .0002	----	----
Cobalt	< .01 (mg/l)	.01-.019	.013	.01-.017	<.01	<.01-.08
Copper	< .01 (mg/l)	.01-.017	.022	.01-.17	.011	<.005-.17
Iron	.21 (mg/l)	.117-.653	.3	< .05	.19	.032-.509
Lead	.003 (mg/l)	.002-.005	.003	.002-.005	.008	<.05-.03
Manganese	.162 (mg/l)	.109-.226	.05	< .01	.06	<.01-1.2
Mercury	.05 (ug/l)	.05-.25	.001	.0002	----	----
Nickel	< .02 (mg/l)	<.02	----	----	----	----
Selenium	< .1 (mg/l)	<.1	.01	.002	----	----
Tin	< .03 (mg/l)	<.03	----	----	----	----
Vanadium	< .01 (mg/l)	<.01	----	----	----	----
Zinc	.02 (mg/l)	<.01-.15	5.0	< 5.0	.014	.22-5.0

LEAD

SAMPLING DATE

	July 12	August 2	August 23	September 24	October 25
Station 01	0m - <.002	0m - <.002	0m - .003	0m - <.002	0m - <.002
02	0m - <.002	0m - <.002	0m - .002	0m - <.002	0m - <.002
	2m - <.002	2m - <.002	2m - .002	2m - .002	5m - <.002
	3m - <.002	4m - <.002	4.5m - .003	5m - <.002	11m - <.002
03	2.5m - .003	2m - .002	2.25m - .004	2.25m - <.002	2.25m - <.002
04	1m - .002	.6m - <.002	1m - .002	.5m - <.002	.5m - <.002
05	3m - .002	3m - <.002	3m - .003	3m - <.002	3m - <.002
06	2m - <.002		2m - .002	3m - <.002	3m - <.002
07	2.5m - <.002	2.5m - .003	2.5 - .002	2.5m - <.002	2.5m - <.002
	5m - <.002	5m - <.002	5m - .003	4m - <.002	4m - <.002
	7m - <.002	8m - <.002	7.5m - .004	7.5 - <.002	7.5m - <.002
08	0m - <.002		0m - <.002	0m - .005	0m - <.002
09	2m - <.002	2m - <.002	2m - <.002	2m - .002	2m - <.002
10	0m - .002	0m - <.002	0m - <.002	0m - <.002	0m - .004
11	1.5m - <.002		1.5m - <.002	1.5m - <.002	1.5m - <.002
12	0m - <.002	0m - <.002	0m - <.002	0m - .002	0m - <.002
	2m - <.002	2m - <.002	2m - <.002	2m - <.002	2m - <.002
	4m - .002	4m - <.002	4m - <.002	4m - <.002	4m - <.002
13	0m - .002		0m - <.002	0m - <.002	0m - <.002
14	0m - .002		0m - <.002	0m - <.002	0m - <.002
15	1m - <.002		1m - <.002	.5m - <.002	2m - <.002
16		.75m - <.002	.75m - <.002	1m - .002	1m - <.002
17		0m - <.002	2m - .003	2m - <.002	1m - <.002
18		1m - <.002	0m - <.002	0m - <.002	0m - <.002
		2m - .003	0m - <.002	0m - <.002	
19		0m - <.002	0m - <.002	0m - .002	0m - <.002